Fall 2014

Culturally responsive engineering education: A case study of a pre-college introductory engineering course at Tibetan Children's Village School of Selakui

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Graduate School Form 30
(Revised 08/14)

PURDUE UNIVERSITY
GRADUATE SCHOOL
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By Marisol Mercado Santiago

Entitled
Culturally Responsive Engineering Education: A Case Study of Pre-College Introductory Course at Tibetan Children's Village School of Selakui

For the degree of Doctor of Philosophy

Is approved by the final examining committee:

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Approved by: Ruth Streveler 11/14/2014

Head of the Department Graduate Program Date

CULTURALLY RESPONSIVE ENGINEERING EDUCATION: A CASE STUDY OF A PRE-COLLEGE INTRODUCTORY ENGINEERING COURSE AT TIBETAN CHILDREN'S VILLAGE SCHOOL OF SELAKUI

A Dissertation

Submitted to the Faculty

of

Purdue University

by

Marisol Mercado Santiago

In Partial Fulfillment of the

Requirements for the Degree

of

Doctor of Philosophy

December 2014

Purdue University

West Lafayette, Indiana

Esta tesis la dedico a mis primeras maestras: mi madre y madrina (tía). La dedico póstumamente a mi abuela, Blanca N. de la Cruz Martínez, y a mi abuelo, Miguel Santiago Arce. La dedico como ofrenda a los Budas, el Dharma y la Sangha.

Que tod@s l@s estudiantes obtengan becas y las circumstancias favorables para apoyar sus estudios, aspiraciones y vida.

I dedicate this thesis to my first teachers: my mother and Godmother (aunt). I dedicate it posthumously to my grandmother, Blanca N. de la Cruz Martínez, and my grandfather, Miguel Santiago Arce. I dedicate it as an offering to the Buddhas, Dharma, and Sangha.

May all students have scholarships and the circumstances to support their studies, aspirations, and life.

ACKNOWLEDGEMENTS

Thanks to professors Alice L. Pawley, Donald W. Mitchell, Brent K. Jesiek, Ruth A. Streveler, Demetra Evangelou, Myrdene Anderson, Alberto López-Carrasquillo, Juan C. Lucena, and Robin S. Adams because they were important mentors in my doctoral studies. Thanks to the FREE research group at Purdue University. Thanks to the unconditional support of Lawrence. Thanks to Luz N. Quintana-Luciano, Carlos A. Santiago-Quintana, and Fredeswinda Méndez-Pérez. Thanks to the following groups or organizations: Tibetan Mongolian Buddhist Cultural Center, staff members and students at Tibetan Children's Village Schools of Selakui and Dharamsala, the Buddhist groups of Indiana, Ganden Shedrub Ling Buddhist Center, Dharmadatta Nuns Community, and Sakya College for Nuns. Thanks to S.T. and Y.R.

Thanks to my participants and students: the backbone of my thesis.

Disclaimer:

This material is based upon work supported by the National Science Foundation Graduate Research Fellowship Program under Grant No. DGE-1333468. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the view of the National Science Foundation. In addition, the conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the view of Tibetan Children's Village Schools.

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ABSTRACT

Santiago, M. M. Ph.D., Purdue University, December 2014. Culturally Responsive Engineering Education: A Case Study of a Pre-College Introductory Engineering Course at Tibetan Children's Village School of Selakui. Major Professor: Alice L. Pawley.

Culturally responsive teaching has been argued to be effective in the education of Indigenous youth. This approach emphasizes the legitimacy of a group's cultural heritage, helps to associate abstract academic knowledge with the group's sociocultural context, seeks to incorporate a variety of strategies to engage students who have different learning styles, and strives to integrate multicultural information in the educational contents, among other considerations.

In this work, I explore the outcomes of a culturally responsive introductory engineering short course that I developed and taught to Tibetan students at Tibetan Children's Village of Selakui (TCV; in Uttarakhand, India). Based on my ethnographic research in Tibetan communities in northern India (Dharamsala and Dehradun), I examine two research questions: (a) What are the processes to develop and implement a pre-college culturally responsive introductory engineering course? and (b) How do Tibetan culture and Buddhism influence the engineering design and teamwork of pre-college Tibetan students in India?

I designed then taught the course that featured elementary lectures on sustainability, introductory engineering design, energy alternatives, and manufacturing engineering. The course also included a pre-college engineering design project through which Tibetan high school students investigated a problem at the school and designed a possible solution to it.

I collected data using ethnographic research methods. I obtained data from interviews with Tibetan and Indian teachers, interviews with Tibetan engineers, students' design progress reports, students' pre- and post-course questionnaires, students' final project presentations, observations in class, fieldwork reflections, videos of my classes and feedback sessions, and videos of some students' implementation phase. The research study design was a case study with eight units of analysis in the form of eight student team design projects. The data analysis was achieved through grounded theory methods. After I coded the data sources with the aid of a qualitative research software package, I passed through several iterations of axial and selective coding. I interpreted the data associated with themes. The interpretations formed narratives (storylines) that were triangulated with my participants' responses and fieldnotes. I made use of data displays (e.g., concept maps and matrixes) to visualize the data connections or to make comparisons.

Drawing from postcolonial studies, engineering studies, engineering and social justice, Buddhist studies, and Tibetan studies, I provide an analysis of my findings. Based on my findings, I conclude that my culturally responsive approach of teaching was an effective method to help students feel that their cultural background was respected and included in a pre-college engineering course; however, some students felt resistance toward the teaching approach. In addition, the culturally relevant content that connected with their ways of living in their school, Tibetan communities, and surroundings helped the students to relate to abstract concepts in familiar settings. Lastly, they appreciated that I brought to the course relevant information about technology and society in India (the host country), engineers' work in industry, technologies used in other contexts, and projects that show how engineers can help to alleviate poverty.

The findings of my research can inform (a) educators who are interested in integrating culturally responsive activities in their pedagogical methods, (b) researchers who wish to conduct education research in ethnic minority schools abroad, (c) educators interested in developing engineering activities or courses for underrepresented ethnic minorities or some ethnic diasporas or refugee youth in the United States, and (d) facilitators at multicultural engineering summer camps.

CHAPTER 1. INTRODUCTION

1.1 Purpose of the study

The purpose of this exploratory case study (Yin, 2009) was to (a) identify the procedures to develop and implement a culturally responsive pre-college introductory engineering course at Tibetan Children's Village (TCV) School of Selakui (in Uttarakhand, India) and (b) identify how Tibetan culture and Buddhism influence the design and teamwork of the Tibetan students who participated in the course.

TCV Schools is a charitable organization that provides primary and secondary education to Tibetans in exile in India (Head Office, Tibetan Children's Villages, 2007). The system consists of eight residential schools (Tibetan Children's Villages, n.d.b.) and four day schools (Tibetan Children's Villages, n.d.a.). According to its educational manual, its mission is "to ensure that all Tibetan Children under its care receive a sound education, a firm cultural identity and become self-reliant and contributing members of the Tibetan community and the world at large" (Head Office, Tibetan Children's Villages, 2007, p. xiv).

1.2 Importance and motivation

Diversity in engineering education continues to be of considerable concern to American engineering educators (National Academy of Engineering, 2004, 2008). Many diversity-related educational efforts have focused on training children with diverse backgrounds to succeed in conventional classrooms (Banks, 2003). A different teaching approach stems from the recognition that students' different sociocultural backgrounds affect their overall understanding of engineering concepts and design and their interaction with other fellow students. In the engineering education field, Baillie, Ko, Newstetter, and Radcliffe (2011) called attention to the need to take into account the experiences and ways of knowing (epistemologies) of diverse populations, including students who belong to cultural groups that may not have a Western world view. In addition, Svarovsky and Bequette (Grantome, 2014) are exploring the outcomes of culturally relevant Maker experiences (informal learning through problem-solving, design, and construction of things) to engage underrepresented populations in science, technology, engineering, or mathematics (STEM). Moreover, sustainability is increasingly important in engineering education, and some have argued that engineering educators might use sustainability in educational contexts to increase the interest in engineering of underrepresented minority groups (Cardella, Hoffmann, Ohland, & Pawley, 2010).

My motivations for undertaking this particular research project were to combine my interests (e.g., Buddhist and Tibetan studies) into exploring teaching methods to educating diverse populations. I connected my personal motivations, interests, and identities with gaps in literature in the engineering education field. Through a National

Science Foundation Graduate Research Fellowship (NSFGRF), an Alliance for Graduate Education and the Professoriate (AGEP) grant, my enthusiasm and perseverance, my adviser's and committee's expertise, and the close people who supported me personally and academically, I was able to accomplish it.

The research project can provide insights to engineering educators. By learning about the teamwork and design processes of pre-college Tibetan students and about my pre-college culturally responsive engineering education intervention, they can develop other pre-college engineering education interventions for underrepresented ethnic minorities, or ethnic diaspora or refugee youth in the United States.

1.3 Components of my doctoral study

In this section, I will provide a summary of the main components of my doctoral project: (a) the course content and pedagogy, (b) pre-college design project experience, and (c) research.

1.3.1 Course content and pedagogy

I proposed a pre-college introductory engineering short course offered to high school–level students aged 16 and older at Tibetan Children's Village School of Selakui (in Uttarakhand, India).[1] The course started on September 3, 2012, and ended on October

[1] For a background summary of the school, refer to chapter 2, section 2.3.

10, 2012, the day of the final projects presentations. The recruited students expressed either an interest in studying engineering or simply learning something new.

Table 1.1 and Table 1.2 indicate the demographics separated by gender. I purposely recruited only ethnic Tibetan students because I wanted to work with refugee Tibetans in northern India, as part of my efforts to support this community. A total of 33 ethnic Tibetan students participated in the course. Twenty-five students were male, and 8 were female. Nineteen male students and 4 female students were born in Tibet. Six male students and 4 female students were born in India. The majority (19 out of 33) were 18 years or older.[2]

Table 1.1 Demographics of Ethnic Tibetan Male Students

	Born in India	Born in Tibet	*Total*
18 years or older	1	14	*15*
16 or 17 years	5	5	*10*
Total	*6*	*19*	*25*

Table 1.2 Demographics of Ethnic Tibetan Female Students

	Born in India	Born in Tibet	*Total*
18 years or older		4	*4*
16 or 17 years	4		*4*
Total	*4*	*4*	*8*

The following course objectives are based on my literature review framework, which is discussed in detail in Chapter 2:[3]

- Provide the students with a general understanding of what is engineering and sustainability, with more emphasis on introductory sustainable design,

[2] The reason why the majority of these high school students are adults is explained in chapter 4, section 4.5.2.1.

[3] A copy of the original syllabus is found in Appendix CC.

sustainable energy technologies, basics of products design (from the perspective of manufacturing), and general (engineering) career mentoring.

- Help the students to understand the connection between engineering and society (and vice versa).
- Provide the students with a hands-on and teamwork experience in pre-college engineering design through a project.
- Help the students to reflect on how their values, beliefs, and identities as Tibetans influence their design and teamwork.

Based on what I was learning from the school and teachers during my stay before teaching the course, I designed a total of eight lectures in the form of electronic presentations.[4]

1.1: What is engineering?

1.2: Engineering and society

2.1: Basic concepts of products design

2.2: Basic concepts of structural engineering

3.1: What is sustainability?

3.2: Examples of sustainable engineering designs

4.1: Energy and energy alternatives

4.2: How do alternative energy technologies work?

[4] I did not give Lecture 2.2 because on that day the students did community service work to prepare the school for an important event held on September 15, 2012 (Dalai Lama's visit to the school).

Some of the lectures had supplementary documents related to the content. In addition, the students received printed-out copies of the electronic presentations.[5]

1.3.2 Pre-college design project experience

The course required students to participate in a pre-college design project in teams. The objective was to provide them with the opportunity to experience a pre-college design project similar to a pre-college engineering design summer camp or a first-year engineering project. The 33 students formed eight teams by themselves. Each team had between three and five students. Table 1.3 provides the team demographics:[6] number of students per team, age, gender, birthplace, and, in some cases, specific region of Tibet where they were born. All personal identifiers have been omitted.

Table 1.3 Demographics per Team

Team	No. of males	No. of females	Ages (each number represents the age of a team member)	Birth Place
1	4	0	19, 20, 20, 22	All were born in Tibet
2	4	1	18, 18, 18, 19, 20	All were born in Tibet
3	4	0	16, 17, 17, 17	Two were born in India, two were born in Tibet
4	2	2	16, 17, 19, 21	Two were born in India. Two were born in Tibet.
5	5	0	16, 16, 16, 21, 22	Four were born in Tibet. One in India.
6	3	1	16, 16, 19, 20	Three were born in India. One in Tibet.
7	0	3	17, 19, 19	Two were born in Tibet. One in India.
8	3	1	16, 16, 18, 22	Three were born in Tibet. One in India.

[5] Due to copyright limitations I cannot include a copy of the lectures in the Appendix.
[6] I show the demographics per team and not per student because my units of analysis were each team. For an explanation about the research methods, refer to Chapter 3.

The course syllabus (Appendix CC) provided general information about what the students would learn during the lectures and about the project. The instructions relevant to the design project were also provided in the course syllabus, and the students received reminders about the instructions during class and the feedback sessions that I scheduled with each team. The students were aided by "design progress report guidelines" (Appendixes A to D), which contained special instructions for all teams. Each team received feedback or instructions from me depending on their particular needs, struggles, and progress.

Table 1.4 displays the instructions relevant to the design project (edited from the original to improve the readability). In an attempt to be responsive to the school's mission and inclusive of the Tibetan Buddhist values that it follows, I presented a framework of engineering design based on the Four Noble Truths, which are the principal teachings of Buddha Shakyamuni,[7] who is regarded as the founder of Buddhism. Each "truth" is associated with a "stage" in the engineering design cycle. This idea is derived from a chapter that I wrote for the book *Engineering Education for Social Justice: Critical Explorations and Opportunities*, edited by J. C. Lucena (refer to Santiago, 2013).

[7] For an introduction to Buddhism, see chapter 2, section 2.4.

Table 1.4 General Rules for the Design Project

In your team, you will work to accomplish the following:

a. *Identify* a problem (need) in your school: research more to understand it
    i. The project will address a real need in your school
b. *Apply* science knowledge and creativity to help solve it
c. *Reflect* on the following: how your Tibetan identity, beliefs, and values help you with teamwork and solving the problem

Distribution of tasks in the group:
You will arrange with your group a fair distribution of tasks in order to complete the project. If you need to rotate tasks every week, then please do so. You can use your previous knowledge working on *shenpen* activities or other school teams to manage teamwork.

General rules:

- You will work in a group of four students (only one group will have 3 students)
- You will pass through a four-phase engineering design project. It is based on the Four Noble Truths:

- In your group, after you research the need in your school, use geometry, physics, and other scientific principles to create a solution for the problem.
- The need (problem) that you choose must be something that you are comfortable working with.
- You can ask others in your school to help you (example: people with more carpentry knowledge); however, you have to write in your report which person helped you.
- For the project, use materials that are environmentally friendly. It would be great if they are locally available. You can recycle/reuse things.

The main objective was to provide the students with an opportunity to experience engineering design and teamwork similar to those of a first-year engineering project, adapted to pre-college level, coached (or guided) by me through individualized feedback sessions, and inclusive of the altruistic values in their Buddhist-influenced culture to be "culturally responsive." The project approach was also similar to the community service and experiential learning activities that TCV of Selakui implemented in the daily after-school activities that students undertake in groups under the supervision of school administrators. These groups are called *shenpen* (Tibetan for "others before self"). Each *shenpen* group has a theme (cultural, environmental, or welfare), and the tasks that each group undertakes are aligned to the group's theme.

1.3.3 Doctoral research

The course was part of my doctoral research in Engineering Education at the School of Engineering Education in Purdue University. Because of my interests, which I connected to gaps in literature in the engineering education field (see sections 1.2, 2.5, 2.6.4, and 2.6.5), I wanted to obtain qualitative data through ethnographic research methods to answer my two research questions:

1. What are the processes to develop and implement a pre-college culturally responsive introductory engineering course?
2. How do Tibetan culture and Buddhism influence the engineering design and teamwork of Tibetan students in the pre-college introductory engineering course taught at Tibetan Children's Village School of Selakui?

In 2010, I approached Arjia Rinpoche, director of the Tibetan Mongolian Cultural Center in Bloomington, Indiana to talk about the project and the need to find a suitable school to teach and research the course that I proposed. In-person meetings and e-mail communications were maintained for more than a year because I had challenges communicating my project ideas to him and he had challenges communicating the ideas to people in India who could help us obtain a letter of permission to access a school. In late 2011, we were finally able to obtain a letter of permission to conduct research at Norbulingka Institute in Dharamsala. My adviser (Dr. Alice L. Pawley) and I wrote the letter to help them understand what we needed.

After I got the letter signed, I started the researcher's visa application process. After I got the visa, I made arrangements to travel to India in late March 2012. I stayed in Dharamsala, Himachal Pradesh until June 2012. While in Dharamsala, I held meetings at Norbulingka Institute. I realized that it was not the right school to teach the course,[8] with my own effort I managed to have a meeting with the education director of TCV, Ms. Sonam Dholkar Samkhar-la. She asked me to meet in person with the principal of TCV Selakui, Mr. Duke Tsering-la. I traveled to the state of Uttarakhand to meet with the principal and the students to explain my project. After we reached an agreement, I came back to Dharamsala to revise my IRB protocol. In June 2012, I moved to the town of Selakui in the state of Uttarakhand to start my fieldwork.

During the months of June until I started teaching in September 2012, I was interviewing participants at the school and outside of it. Every day, I reflected on what I was learning on the field about the school, students, events, activities, and my interviews. According to my reflections, I wrote next steps (e.g., a list of actions) to do on the field or questions to ask to gain more insights on phenomena associated with my research questions. After I taught the course, I moved back to Dharamsala to conduct other

[8] Section 3.4.2 discuss this issue in more detail.

interviews. My fieldwork ended on December 23, 2012 and I traveled back to Indiana on December 26, 2012.

The research design was an exploratory case study (Yin, 2009). It was "exploratory" because the published data about culturally responsive engineering education and culturally responsive teaching in STEM education is scarce. To answer my research questions, I designed data collection instruments (see Appendixes I to Q). I collected the data through fieldnotes, observations, students' pre- and post-course questionnaires, teams' design progress reports, teams' final projects presentations, videos of the classes (including the final project presentation and feedback sessions), and photos of the students' projects. I used decolonizing research methodologies (Smith, 1999) throughout my data collection fieldwork. In Chapter 3, I will explain my data collection methods and methodology in more detail.

In the data analysis, I used grounded theory research methods (Birks & Mills, 2011; Strauss & Corbin, 1998) to identify themes in the data. My data analysis was written through the lens of postcolonial theory,[9] based on the work of Edward W. Said (1994), Donald S. López (1998), James G. Carrier (1992; 1995), and Dibesh Anand (2000; 2003; 2007). In addition, I drew on Tibetan studies, Buddhist studies, intercultural education, and engineering education and social justice references (EESJ) to support my arguments and triangulate my data. In Chapter 3, section 3.6, I provide the details of the data analysis methods.

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[9] For an introduction of postcolonial theory, refer to chapter 3, section 3.6.1.1, which also explains the reference to these authors.

1.4 Contributions of this study

I believe that the principal contribution of this study is that it can inform the development and teaching of other pre-college culturally responsive engineering education interventions for Indigenous groups, some ethnic diasporas (e.g., Puerto Ricans), and some refugee cultural groups in the United States. This assumption is based on a postcolonial perspective because some of these groups have shared experiences of either colonization(s) or complex ideological (or even religious) conflicts that have led to divisions within the cultural group. When some students from these backgrounds enter engineering education contexts, additional considerations should be incorporated into the teaching or development of engineering educational interventions so that students can develop trust in their teachers and teachers can serve better their students.

From a postcolonial perspective, I argue that, because of the reality of globalization, history of colonization(s), and ideological (or religious) conflicts in the present or past of Native American tribal groups, ethnic refugees, or ethnic diasporas, teachers no longer should assume that every cultural or ethnic group shares the same interpretations and experiences of their own culture (and even religion coupled in their culture). Therefore, culturally responsive teachers should be mindful of what sociocultural elements from a student's background are being used to associate academic abstractions to avoid creating unnecessary barriers between the students and teachers. In Chapter 4 and 5, I discuss findings that are aligned with this issue. For example, in Chapter 4, I present the processes involved in developing the course including improving my understanding of how the Tibetan students' refugee situation impacts their education.

In Chapter 5, I talk about the Tibetan Buddhist laypersons' experience of Buddhism. I argue that the course approach to help students reflect on how the six virtues of the *Mahāyāna-Bodhisattva* path support their teamwork and design was aligned to their Buddhist background; however, their reflections were based on their reality as *laypersons* in the context of a pre-college engineering design project. Therefore, because of the particular experiences of these groups of people, I believe that these research findings can provide insights to teachers who teach or develop course content targeted to some of these Indigenous, ethnic diaspora or refugee groups in the United States.

Few studies research the issues of education for Tibetans in the diaspora (in South Asia and the Western world), according to Phuntsog (1998) and Rigzin (2003). The cultural Tibet has been extending beyond Asia in part because of the increasing attention paid to Tibetan struggles by the Western media and the international travels of the 14th Dalai Lama[10] as a consequence of his exile from Tibet[11] (Roemer, 2008). Globalization has also contributed to this expansion of Tibetan culture, and scholars interested in (a) expansions of cultures throughout the world, (b) the construction and reconstruction of cultures in other parts of the world, (c) and how these other cultural beliefs are directly or indirectly influencing the Western world can also benefit from my research findings.

In addition, postcolonial scholars can obtain insights from what I learned teaching a culturally responsive course, because my perspective is aligned to the postcolonial critique of the Western construction of Buddhism and how it may clash with the Buddhism as known in traditional Buddhist societies (in general). For example, as I

[10] He is regarded as the most important religious leader of Tibetan Buddhism.
[11] For a historical account of Tibetans in exile, refer to chapter 2, section 2.2.

explain in Chapter 4, in order for me to develop and teach in Tibetan communities in exile in India, I had to understand how their refugee status in India has impacted their education, which includes the adoption of India's Central Board of Secondary Education standards in their high school educational system so that students can obtain a high school diploma that is acceptable to India's universities. This is important to understand because, as I explain in Chapter 4, their learning is influenced by not only Tibetan culture and Buddhism but also their particular needs as refugee individuals in India as well as the politics of the Tibetan government-in-exile.

Giles and Dorjee (2005) noted that there is a gap in research on Tibetan-American families to understand cultural adherence and negotiation in comparison with other immigrant families. Maslak (2008) explained that there is a dearth of research on Tibetan schools in India in terms of how they function, the teachers' work, and the textbook content used by teachers and students. Moreover, there are few research studies on the importance of cultural identity in the education of Tibetans in the diaspora (Maslak, 2008).

Because of the dearth of literature in the development and implementation of culturally responsive engineering education courses for Native American, ethnic diaspora or ethnic refugee groups, which can be inclusive of their cultural identities and values, I believe that my research and education project can fill a gap in the engineering education field and can guide other teachers to develop similar interventions.

1.5 Organization of the thesis

This thesis has a total of seven chapters. Chapter 2 describes the theoretical framework on which I based the course design and pedagogy, as well as the relevance of my study in other frameworks (e.g., constructivism, experiential learning, community service learning, sustainability education, and multiculturality in engineering teams). Chapter 3 discusses my research methods, methodology, and the framework of my data analysis. Chapter 4 discusses my process of developing and implementing the course, which answers the research question: "What are the processes to develop and implement a pre-college culturally responsive introductory engineering course?" Chapters 5 and 6 present the findings regarding the research question: "How do Tibetan culture and Buddhism influence the engineering design and teamwork of Tibetan students in the pre-college introductory engineering course taught at Tibetan Children's Village School of Selakui?" Both chapters present the findings by team (project). As discussed in Chapter 3, section 3.2, each team's project is treated as a unit of analysis in the case study to assist in answering the research question about Tibetan culture and Buddhism. Finally, Chapter 7 summarizes the major findings of Chapters 4 to 6, discusses the limitations of the study, and presents possible future research directions.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

In this chapter, I provide the literature framework on which I based the course pedagogy, content, and design project. In addition, I review the literature on multicultural engineering teams and sustainability education relevant to situate my study in these efforts by other scholars. The major sections are: (a) brief historical account of the Tibetan people in exile, (b) brief background of the school site (Tibetan Children's Village of Selakui), (c) introduction to the *Mahāyāna* School of Buddhism, Tibetan Buddhism, and Socially Engaged Buddhism, (d) research on multicultural engineering teams, (e) research on sustainability education, and (f) theories that informed the content and pedagogy of the introductory engineering course, and (g) relevance of my findings in other frameworks. Before starting each section, I describe why I included the section in light of my research questions. At the end of this chapter, I provide a framework diagram to assist in visualization of the components of the introductory engineering course.

2.2 Brief historical account of Tibetan people in exile

I included this section to help you understand why there are Tibetans living in India and their historical background starting from the late 1940s. *This historical background is not meant to be comprehensive, but an overview* of what happened that made them flee (and continue fleeing) from Tibet. The section is particularly relevant to my second research question because the question specifies the main population of the study who are Tibetans in exile in India.

On October 1, 1949, Mao Zedung proclaimed the People's Republic of China (PRC) (Pommaret, 2003). In 1950, the People's Liberation Army (PLA) troops occupied Tibet (Pommaret, 2003). From the perspective of the Chinese government, Tibet had been part of China for centuries, and the objective was to liberate Tibetans from feudalism and a medieval society by means of a political transformation that would bring modernization and progress (Pommaret, 2003; Kapstein, 2006). From the perspective of Tibetans in exile—one of the perspectives that has been brought to the West—Tibet was occupied by China, and China was deeply interested in Tibet because of its land, resources (valuable minerals and their rivers), and geographical position in Asia (Pommaret, 2003).

Tibetans did not have China's military strength, and within its monastic, aristocratic, and nomadic communities there occurred a split between those who were sympathetic to the Chinese occupation and those who did not (Shakya, 1999). On May 23, 1951, Tibetan and Chinese delegations signed the "17-Point Agreement" with the expectation that the Chinese government was going to honor its agreements on preserving

Tibet's political system, culture, and religion (Shakya, 1999). However, as time passed, Tibetans (especially those from Amdo and Kham) observed that the Chinese government was dishonoring the agreement (Shakya, 1999). In 1955, Tibetans in Amdo and Kham regions had uprisings against China's measures to change their nomadic livelihoods (Shakya, 1999). Thousands of Khampas[12] fled to India after they noticed that their reports about violence and destruction caused by the Chinese government initially were not taken seriously by some Tibetans in Lhasa (Shakya, 1999). In the following years (1956 and 1957) tensions grew stronger and thousands of Khampas migrated to central Tibet (Shakya, 1999). By late 1957, different groups united against the Chinese government, not only the Khampas (Shakya, 1999). The situation continued to deteriorate. On March 10, 1959 there was an uprising in Lhasa to express the anger against the Chinese government and resentment against the Tibetan rulers because they believed that some rulers betrayed Tenzin Gyatso, the 14th Dalai Lama, who was at that time the religio-political leader of the Tibetan people (Shakya, 1999). On March 30, 1959, the Dalai Lama fled with his entourage to India (Pommaret, 2003). The Prime Minister of India, Jawaharlal Nehru, gave them political asylum (Pommaret, 2003). Between 1959 and 1960, approximately 80,000 Tibetans fled to either India or Nepal because of the violent repression in their homeland (Pommaret, 2003).

The Indian government ceded the old colonial town of McLeod Ganj, above Dharamsala, to the Dalai Lama (Kapstein, 2006; Pommaret, 2003). In 1960, the Tibetan exiles established a government-in-exile and began to reorganize their monasteries,

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[12] People from the Kham region of Tibet.

libraries, administrative centers, record-keeping offices, and schools with the help of foreign and Indian aid (Kapstein, 2006; Pommaret, 2003).

In June 1966, Mao Zedong declared the Cultural Revolution (Pommaret, 2003). He gave commands to oppress the “four olds:” old cultures, old ideas, old traditions, and old customs (Pommaret, 2003). As part of this political change, Tibetan customs and traditions were replaced by revolutionary words, phrases, operas, and other artistic expressions consonant with the Cultural Revolution (Pommaret, 2003).

On September 21, 1987, the Dalai Lama presented his Five Point Peace Plan to the United States Congressional Human Right's Caucus (Pommaret, 2003). In June of 1988, during a visit to the European Parliament in Strasbourg, France, the Dalai Lama proposed his position of nonviolence and a new autonomous Tibet, not under the old 17-Point Agreement (Pommaret, 2003). This proposal included the vision of a new Tibet where Tibetans have full responsibility for their children, education, religion, cultural affairs, environmental conservation and restoration, and local economy (Pommaret, 2003). This proposal was called the “Strasbourg Proposal” or the “Middle Way Approach” (Pommaret, 2003).

Currently, some Tibetans favor independence over the Middle Way Approach[13] (Tsering, 2012; Norbu, 2012). Certainly, the current circumstances in Tibet make the case for political change more challenging: China has increased control over its borders with India and Nepal; there has been a mass mobilization of the Han Chinese population to Tibet; and transnational companies have increased interests in Tibet’s resources

[13] The Middle Way Approach is a policy adopted by the Central Tibetan Administration (the Tibetan-government-in-exile) which calls for genuine autonomy for Tibet rather than complete independence from China as a way to solve Tibet’s political issue (The Office of His Holiness the Dalai Lama, n.d.).

(Grammaticas, 2010; Rajan, 2010). The Chinese media calls the Dalai Lama a separatist, and any attempt to address Tibet's situation as an international concern is rejected by the Chinese government because it considers it to be an internal issue (Pommaret, 2003).

Because of these political and religious conflicts, many Tibetans left (and continue to leave) their ancestral land to reach primarily India or Nepal. Some of the young Tibetans who cross the border are enrolled in Tibetan Children's Village (TCV) Schools (among other school systems); therefore, TCV Schools system have become a pillar of the preservation of Tibetan cultural identity among Tibetans youth in exile in India.

2.3 Brief historical background of Tibetan Children's Villages and TCV of Selakui

I included this section to help the reader understand the context of research that is TCV School of Selakui. Because the school is part of a system of schools, I also included a brief summary of the TCV school system. It is relevant to the first research question because one needs to know more about the context of the school where I developed and taught the course. In addition, it is relevant to the second research question because the students were doing their design projects at the school site.

TCV was founded in 1960 as a nursery for Tibetan orphans and those who were separated from their families during their fled (Tibetan Children's Villages, n.d.c.). In the 1970s, it became affiliated with an international organization: S.O.S. Kinderdorf International (Wieder, 1999).

TCV Schools implement daily activities under the framework of holistic education and experiential learning (Head Office, Tibetan Children's Villages, 2007). The educational manual also refers to forms of collaborative, cooperative, and community service learning activities, which are forms of learning that are aligned with their cultural values (Head Office, Tibetan Children's Villages, 2007).

The structure of TCV Schools is based on the Indian education system: 6 years of elementary school, 4 of middle school, and 4 of high school (Palkyi, 2011). The "TCV Educational Manual" (Head Office, Tibetan Children's Villages, 2007) stated the following about the structure of the education system that help students to obtain a secondary school diploma that could be honored in higher education institutions:

> The Tibetan Children's Village schools follow the 10 plus 2 system of education of the host country. The schools prepare students for the All India Secondary School and All India Senior Secondary Certificate Examinations conducted by the Central Board of Secondary Education, New Delhi. (p. 99)

Until class 5,[14] Tibetan is the language of instruction (Head Office, Tibetan Children's Villages, 2007). Starting in class 6,[15] classes are taught in English and Hindi is taught as a third language (Head Office, Tibetan Children's Villages, 2007). Classes 9 and 10[16] offer the following subjects: "Tibetan, English, General Science (physics, chemistry, and biology), Social Science (history, civics, geography, economics)" (Head Office, Tibetan Children's Villages, 2007, p. 99). Classes 10+1 and 10+2 follow the course streams of CBSE (Head Office, Tibetan Children's Villages, 2007). In the case of

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[14] Equivalent to fifth grade in the American school system.
[15] Equivalent to sixth grade in the American school system.
[16] Equivalent to ninth and tenth grades respectively.

TCV Selakui, they only offer the CBSE science stream in 10+1 and 10+2 that is divided in “medical” and “nonmedical” streams. I have dedicated section 4.5.1.1 to discuss the CBSE science stream at the school.

TCV Selakui, the school branch where I taught the course, was opened in 2004 with the objective to provide an educational environment for Tibetan students who are considered gifted children (Head Office, Tibetan Children’s Villages, 2007). The TCV Educational Manual (Head Office, Tibetan Children’s Villages, 2007) states the following about the school:

> Ama Jetsun Pema la recognized the need to start a special school where the space and environment for students who have the capacity to excel in academics and other fields could be enhanced. The TCV Governing Body endorsed the plan and the school started in 2004 as planned. Students are selected at class V level from all the TCV schools through the performance in the TCV Common Examinations and school term exams for three successive years. The school has facilities to provide a good education and is recognized by CBSE [Central Board of Secondary Education], New Delhi. Plans are on the anvil to upgrade the school to +2 level by 2008. (p. 9)

Currently, TCV Selakui offers 10+2 level, which means that students can attend what is equivalent to 12^{th} grade in some Western schools. According to data available at the TCV Selakui Blog (2014), as of 2014, there are a total of 421 students. See Table 2.1 for total of students per class section. For a table with a list of course subjects per class level, refer to Table 2.2.

Table 2.1 Total of Students per Class as of 2014

Class	*Total*
VI A	29
VI B	31
VII A	29
VII B	29
VIII A	30
VIII B	28
IX A	22
IX B	23
X A	28
X B	29
XI A	43
XI B	34
XII A	32
XII B	34
Total	*421*

Table 2.2 Courses per Class Level

Class	Courses
VI–VIII	*Required*: English, Tibetan, Hindi, Math, Science, Social Science, Physical Education, and Computer; plus one lesson of each of the following courses: Visual Arts and Dance & Music.
IX - X	*Required*: English, Tibetan, Math, Science, Social Science, Physical Education, and Foundations of IT; plus one lesson of each of the following courses: Visual Arts and Dance & Music.
XI - XII	*Required*: English, Tibetan, Physics, Chemistry, and Physical Education. If the student opts for the "medical stream," Biology will be *required*. Computer is *optional*. If the student opts for the "nonmedical stream," Math will be *required*. Computer is *optional*.

Photos of TCV Selakui are in Figures 2.1 and 2.2.

Figure 2.1 One of the two main classroom buildings of TCV Selakui

Figure 2.2 Students listening to a discussion at the school auditorium

2.4 The *Mahāyāna* school of Buddhism, Tibetan Buddhism, and the Socially Engaged Buddhist Movement

Sections 2.4 (including its subsections) is relevant to the second research question because part of the question is to examine how Buddhism influences the design and teamwork experiences of the Buddhist Tibetan students who took my course.

Buddhism is the name given to traditions that stemmed from the teachings of Gautama Buddha, who was born in India (c. 563-483 BCE). Some people regard Buddhism as traditions and others as a religion or spirituality. In this section, I provide a brief introduction about the *Mahāyāna* School of Buddhism and Tibetan Buddhism. Because Tibetan Buddhism is a synthesis of *Mahāyāna* and other schools of Buddhism, this information is pertinent to the context of my second research question: "How do Buddhism and Tibetan culture influence the engineering design and teamwork of pre-college Tibetan students?" Finally, I included a brief summary about the Socially Engaged Buddhist movement because I believe that this research project can be part of Socially Engaged Buddhism

TCV Schools has stated in its policy that Buddhism will be part of its modern education system (Head Office, Tibetan Children's Villages, 2007):

> The essence of Tibetan culture is Buddhism. Teaching and learning the philosophy, the methods, and the various paths to transform mind to enable children to relate and help others will be a continuous learning process in life. The groundwork and the fundamentals will be covered in TCV schools. The outcome

> of this exercise is that each child will go forth from the TCV campuses with a clear understanding and appreciation of basic Buddhism.
>
> It is in this area of education, we need to be creative and innovative and introduce programs and activities that actually strengthen the children's character and moral education. Schools can initiate all kinds of programs and activities: by school sections, by classes, by student groups, by teacher groups, by clubs, [etc.]. (p. 126)

In an attempt to be "culturally responsive" and to align my work with the school's missions and values, I thought that I could develop a version of pre-college engineering education that is inclusive of the altruistic Way of the *Bodhisattva*, the heart of the *Mahāyāna* school of Buddhism. Tibetan Buddhism is a synthesis of *Abhidarma*, *Mahāyāna,* and *Vajrayāna* forms of Buddhism (Mitchell, 2008), but I focused on *Mahāyāna*, because *Vajrayāna* has practices that are considered secret, and it is a form of Buddhism that is beyond my current area of study.

I assumed that the Way of the *Bodhisattva* could be transferrable to daily life, including a pre-college engineering design project, an assumption that I demonstrated in my study's findings based on my students' course feedback and the students' responses in the design progress reports (see Chapter 4 and 5 for more detail). Adding to this, I would like to emphasize that my students were Tibetan Buddhist *laypersons*; therefore, they responded to the culturally-relevant questions posited in the design progress reports guidelines *from their laypersons' perspectives.* This is important to note, especially if one is a Westerner who has not lived in a traditional Asian Buddhist society before. Mitchell (2008) explained the differences between the construction of Buddhism in Euro-American and Asian American Buddhist communities:

> Scholars have pointed out that there are certain differences of structure, purpose, and practice between communities founded for Asian American immigrants and communities created for European American converts. For example, ethnic temples serve the social, cultural, and educational as well as the religious needs of the community, while convert communities focus mainly on religious practice. This means that Euro-American converts typically identify with Buddhism through a particular single practice, such as chanting, insight meditation, *kōan* practice, or *dzogchen* training, rather than the broad range of doctrinal and cultural aspects of Buddhism so important to Asian American Buddhists. (p. 379)

In addition to what Mitchell (2008) explained in the paragraph above, Coleman (2001) explained that in Western Buddhism, the distinction between a layperson and monastic is blurred in most traditions. When Asian Buddhists encounter Western Buddhists, they often feel perplexed by them:

> In the new Buddhism, this fundamental distinction between monk and layperson is almost wiped away. Although some people live a more monastic lifestyle while others live as householders, the pursuit of liberation is common to them all. The new Buddhism takes the path of liberation that was preserved and refined by countless generations of Asian monks and offers it up to anyone who is interested. When Asian Buddhists visit the West, they are often confused by Western practitioners they meet. Not really monks but far more involved and dedicated than most laypeople, Western practitioners are hard to classify with the categories their teachers imported from the East. (Coleman, 2001, p. 13)

Now that I have introduced how the construction of Buddhism is different in the "East" and the "West," I will focus on a general introduction without focusing on the perspective of "East" and "West" differences. Section 2.4.1 and 2.4.2 provide a short history and introduction of *Mahāyāna* and Tibetan Buddhism. Section 2.4.3 talks about the Socially Engaged Buddhism movement.

2.4.1 Brief introduction to *Mahāyāna* Buddhism

Mahāyāna Buddhism is one of the three main schools of Buddhism (*Theravada* and *Vajrayāna*) being the other two. The literal English translation is "The Great Vehicle." "*Yāna*" means "vehicle" or "means of motion" in Pali language, "*mahā*" means "great" or "enlarged" (Davids & Stede, 1993). When I asked the research question, "How do Tibetan culture and Buddhism influence engineering design and teamwork…," I am referring to *Mahāyāna* Buddhism, often designated as *Bodhisattvayāna* or the "*Bodhisattva* vehicle" (Mitchell, 2008).

According to Deleanu (2005), *Mahāyāna* Buddhism started as early as the 1st century BCE. New *sūtras* (Buddhists scriptures) were written extolling the "Way of the *Bodhisattva*" as a path that could be practiced by both Buddhist monastics and laypersons, under different presentations appropriate to their roles in a Buddhist society (Mitchell, 2008). This approach to Buddhism tells us that there are "perfections" or "virtues" that should be practiced for thousands of lifetimes (as Buddhists believe in reincarnation and rebirth) for the sake of alleviating the suffering of beings (Mitchell, 2008). Ultimately, the belief is that the practice or "cultivation" of these virtues leads to the highest goal of

Buddhism: *Nirvana* ("Awakening") or the release of oneself from the cycle of *saṃsāra* (the cycle of birth, death, and rebirth) (Mitchell, 2008).

To set the stage for this journey (metaphorically speaking), practitioners have to develop the altruistic aspiration that they are going to undertake the Way of the *Bodhisattva* for the benefit of others, not just for their own liberation from *saṃsāra.* In my own limited understanding, it is as if altruism would be a path with two sides: One side is for alleviating the sufferings of this world (e.g., social injustices) and the other side is for transforming oneself and attaining *Nirvana* (perhaps in hundreds of lifetimes from now), with each side affecting the other.

2.4.2 Brief introduction to Tibetan Buddhism

Approximately, in the sixth century C.E., Tibet became a strong empire (Mitchell, 2008). In the seventh century, King Songsten Gampo (c. 617-649) developed the foundations of Tibetan Buddhism: The Tibetan grammar and alphabet were developed from the Sanskrit model (in order to better translate Indian Buddhist texts) and monasteries were built (Mitchell, 2008). In the eighth century, King Trisong Detsen (c. 742-798) invited Indian and Chinese Buddhist scholars to Tibet. These scholars translated scriptures and brought philosophical ideas and meditative practices to Tibet (Mitchell, 2008).

In 1042, Atīśa arrived in Tibet and incorporated in the Tibetan monastic system a synthesis of *Abhidharma*, *Mahāyāna*, and Indian Tantra (Mitchell, 2008). Mitchell (2008) provided a summary of Atīśa's foundation of the Tibetan Buddhist system that we know now in the Western world:

> One of Atīśa's works, *A Lamp for the Path to Awakening*, gives a survey of this synthesis of the Buddhist path. In brief, Atīśa taught that the monastic life must be guided by the *Vinaya* rules. He believed that the discipline and practice of the early forms of Buddhism like Theravāda provide penetrating insight into the Dharma, which, in turn, gives one an authentic taste of Nirvana. The Buddhist path, Atīśa taught, also needs Mahāyāna's arising of *bodhicitta*, and its gradual bodhisattva way to Buddhahood. Mahāyāna provides the proper understanding of reality in its *sūtras*, and in its fully developed philosophies. Atīśa personally supported the Prāsaṅgika School of Mādhyamika, which became the major school of Tibetan Buddhist philosophy. Finally, Atīśa taught that the bodhisattva journey to Buddhahood could be facilitated and shortened by the practice of Tantric techniques. Tantra was seen by Atīśa as the most powerful means for transforming a common person into a Buddha. As a student of the famous Indian Tantric master Nāropa (1016-1100), Atīśa is also credited with introducing certain Tantric linages of initiations into Tibet. (p. 163)

This construction of Buddhism in Tibet led to the establishment of Tibetan Buddhist linages or sects, in addition to the ancient indigenous tradition *Bön* (Mitchell, 2008). *Nyingma*, *Kagyü*, *Gueluk*, and *Sakya* were the names of these Tibetan Buddhist sects (Mitchell, 2008). All of these sects combine *Mahāyāna* with *Vajrayāna*, but they use different presentations of the result (Mitchell, 2008). *Vajrayāna* is another name for the Tantric practices influenced by Indian Buddhism (Mitchell, 2008). *Vajrayāna* is beyond my area of study and the scope of my research question; therefore, my study's focus is on understanding how the "Way of the *Bodhisattva*" (belonging to *Mahāyāna* Buddhism), represented through the practice of the six virtues (or *pāramitās*), helped Tibetan students in design and teamwork. My assumption was that the practice of the six virtues is supportive of some communication skills that are important in the development of engineers and in the students' design process and teamwork. Those virtues are: generosity, perseverance (joyful effort), patience, mindfulness, ethics (Buddhist morality), and wisdom. In some of my earlier work, (Santiago, 2013) I wrote a more comprehensive description of how I envisioned an introductory engineering course inclusive of the "Way of the *Bodhisattva*" for Buddhist students.

2.4.3 Brief introduction to Socially Engaged Buddhism

As an introduction to Socially Engaged Buddhism, I will quote a short summary that I provided in Santiago (2013):

> *Engaged Buddhism* is a term that has been attributed by Thich Nhat Hanh, a Vietnamese Zen monk. His 14 guidelines for Engaged Buddhism can be found on the Web or in his book "Interbeing: Fourteen Guidelines for Engaged Buddhism. Engaged Buddhism is mindfulness in daily life, social service, and social activism (Puri, 2006). These three aspects, not only connects [*sic*] with human rights, non-violent activism, environmental, social, gender, economic, and political issues, but also encourage people to bring the benefits of their practice in the ordinary life. These movements have taken a more international scope and democratic approach.

> Engaged Buddhism seeks to transform structures of oppression, bringing social justice to daily life, and empower people by acknowledging the Buddha nature in each of us, and our inherent worth and dignity. It seeks to do social justice activism, yet at the same time without discarding the Buddhist emphasis on mindful awareness and a lifestyle that is in harmony with the core teachings of the Buddha (Puri, 2006) [emphasis in original]. (p. 107)

All around the world, Buddhists of all traditions have taken action on poverty and other forms of suffering and oppression. Since I was inspired by these Socially Engaged Buddhist movements to develop and implement the pre-college engineering course that I taught at TCV Selakui, I will give a brief summary of education projects around the world that have been developed by layperson or monastic Buddhists, and which are targeted to children or disadvantaged individuals.

In Sri Lanka, the Sarvodaya Shramadana Movement combines Gandhian and Buddhist thought in education programs on community health, sanitation, development education, meditation, among other areas of need (Rothberg, 1998; Sarvodaya, n.d.). Also in Sri Lanka, the Sakyadhita Center provides Buddhist education camps for children in which they integrate creative activities and arts (Vijithananda, 2011). In Bangkok, Thailand, Mae Chee Sansanee founded the Sathira Dhammasathan Center to offer education programs for women and children (Global Peace Initiatives for Women, n.d.). In Malaysia, Than Hsiang Kalyana Mitra Centre offers Buddhist education camps for children in which they integrate organic farming and recycling education (Shi, 2011). In the United States, the Buddhist Peace Fellowship organizes non-violent manifestations to support global and American social and environmental justice issues (Buddhist Peace

Fellowship, 2012). Finally, two worldwide Buddhist charitable organizations are Buddhist Compassion Relief Tzu Chi Foundation (TCF) and Buddhist Global Relief (BGR) based in the United States. Education is one of the missions of TCF and they have established an education system from Kindergarten to graduate school (Mitchell, 2008). BGR has sponsored worldwide projects in diverse areas. Some of their education-related sponsored projects are in Vietnam (education scholarships), Sri Lanka (technical vocational training for young women), Cambodia (vocational training and skills for women and girls), Bangladesh (education system for children), and Haití (education scholarships), among other countries (Buddhist Global Relief, n.d.).

In the next section, I review the literature on the theories that informed the development and implementation of the course and design project.

2.5 Theories that informed the content and pedagogy of the course

2.5.1 Culturally responsive pedagogy

This section is relevant to both of my research questions because it provides a background of the teaching approach that I used in my course. Culturally responsive pedagogy was coined by American educators such as Gay (2000) and Ladson-Billings (1995). In the United States, this theory postulates that the academic achievement of low-income students of color may improve if their teachers draw upon their language and cultural strengths (Gay, 2000) in the pedagogical methods. This approach can be considered a type of constructivist pedagogy because it authenticates the students' sociocultural background as a means through which teachers can relate the abstract knowledge more effectively to their realities.

The principles of culturally responsive teaching can be summarized in five major points (Gay, 2000):

- It acknowledges the cultural heritage of ethnic groups, both as previous experiences that affect the students' ways of learning (e.g., disposition, attitudes, and approaches) and as valid content to be brought in the curricula.
- It makes meaningful connections between home and school experiences, or between sociocultural realities and academic abstractions. This helps students see concrete examples of academic abstractions in their sociocultural realities.
- It uses a variety of teaching strategies that suit the different learning styles of students.
- It seeks to help students appreciate the cultural heritages of each other.
- It makes use of multicultural information and materials in the classroom.

Researchers have acknowledged the limitations of culturally relevant pedagogy. For example, implementing an educational program that was originally developed for other cultural groups can result in ineffectiveness because of cultural incompatibility (Vogt, Jordan, & Tharp, 1987). In addition, Bartolome (1994) recommended examination of the meaning of "culture" in culturally relevant pedagogy. She argued that teaching methods should identify "the political dimensions of culture and subsequent unequal status attributed to members of different ethnic groups" (p. 185) rather than pursue culturally responsive methods that promote an ethnic congruency.

Morrison, Robbins, and Rose (2008) argued that because most of the studies were conducted in homogeneous classrooms, the effectiveness of the culturally relevant pedagogy could be limited in heterogeneous classrooms. In addition, they noted that the lack of time, resources, and the way education is carried out in modern schools may not provide an inclusive context for culturally relevant pedagogy. Morrison et al. (2008) explained why:

> Schools are currently set up to privilege the transmission theory of learning over the constructivist theory, and the rise of a standardized curriculum and high-stakes tests has only tipped the scales more toward this transmission theory. When teachers are under strong pressure to conform to the standardized curriculum in order to prepare their students for standardized tests, the natural inclination is for them to steer away from allowing their students more voice and choice in the classroom. (p. 444)

Sleeter (2012) argued that the current structures of modern education do not allow culturally responsive pedagogies to flourish, especially because of the influence of neoliberalism.[17] Sleeter (2012) also explained other factors that marginalize culturally relevant pedagogy: (a) the trivialization of the pedagogical approach as a "cultural celebration" (Sleeter, 2012, p. 568), (b) the teacher's essentialization of culture, (c) thinking that culture alone will bring equity, (d) little systematic investigation of the effectiveness of this pedagogy in students' learning and teachers' professional

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[17] Henry A. Giroux (2013) explained that a neoliberal philosophy in the United States education system translates into an education system that replicates the value of the survival-of-the-fittest rather than acknowledging that success in education does not depend solely on individual responsibility; there are factors of race (e.g., institutionalized racism), ethnicity, and class that can impact students' success in school and learning. This in turn translates into the devaluation of culturally responsive pedagogy because it is not aligned to the philosophical values of neoliberalism in the United States.

development, and (e) neoliberals' view of the pedagogical approach in the United States as going against the national hegemony.[18]

For my doctoral research, I wanted to explore the possibilities of this culturally responsive pedagogy in an introductory engineering course for Buddhist Tibetans in India. I implemented the theory in my course through associations among engineering-related abstractions, Tibetan ways of living and familiar things at the school, Buddhist philosophical notions, and multicultural resources (e.g., Indian social issues related to engineering practices and Western contexts of engineering practice). To design my course, I also took inspiration from Eglash (1997) and Greer, Mukhopadhyay, Powell, and Nelson-Barber (2009) work on ethnomathematics and ethnocomputing because they showed how teachers can use the cultural symbols of an ethnic group to help those students understand certain mathematics and computing concepts, while at the same time help the students feel included in the computing or mathematics education community.

In the next section, I discuss another theory that informed the design of my research instruments and course materials.

2.5.2 Theory of transformative learning

This section is also relevant to both of my research questions because it provides a background of the learning theory that I used in my course. My course design and

[18] Critical pedagogy scholars like the author believe that because of the neoliberal political philosophy that views that success in education (or life) depends solely in individual responsibility, and because of the elite class (predominantly White) fears on losing power by losing the established cultural homogeneity in the institutionalized national culture. This in turn translates into the devaluation of culturally responsive education because a goal of the pedagogical approach is to empower students who are perceived to be "outsiders" of the national culture as established by the elite class.

pedagogy were also informed by the theory of transformative learning (TTL) by Jack Mezirow (1991, 2000). This theory was developed through the perspective of constructivism, which states that humans socially construct the meaning of phenomena and things in the world (Kasl & Elias, 2000). I selected TTL as my theory of learning because: (a) it is aligned with constructivism, and therefore I believed it would not conflict with culturally responsive pedagogy, which is also influenced by constructivism; (b) it emphasizes reflexivity as part of the learning process, just like reflective practice has been part of the engineering education and social justice references that I used in my course design (Baillie & Catalano, 2009; Bhatia & Smith, 2008; Lucena, Schneider, & Leydens, 2010); (c) its focus on the transformation of each individual's learning experiences is aligned with the Buddhist notion of impermanence (and Buddhism is part of the course framework of this project); and (d) because its focus is on adult learning, I believed it would be suitable in this environment because the majority of the students were adults (19 out of 33 students were adults).

The theory of transformative learning seeks to understand "the way adult learning is structured and to determine by what processes the frames of reference through which we view and interpret our experience (meaning perspectives) are changed or transformed" (Mezirow, 1991, p. xiii). It seeks to explain (a) how adults make meanings of their life experiences, (b) the cognitive structures that help them construe experiences in the world, (c) the cognitive transformations, and (d) the way that meanings transform when learners find out that their assumptions are dysfunctional in adulthood (Mezirow, 1991, p. xii).

Figure 2.4 illustrates how learning occurs according to the transformative learning theory. Under this theory "[l]earning occurs in one of four ways: by probing novel meaning perspectives, elaborating on existing meaning perspectives, transforming points of view, or transforming habits of mind” (Mezirow, 2000, p. 19; refer to left portion of Figure 2.4). The first two ways of learning mean that teachers can help learners by working with what they already know (e.g., expanding, modifying, or complementing their knowledge) and by working with new compatible knowledge that will co-exist with their existing knowledge (Kitchenham, 2008). The last two ways are regarded as learning through transformation (Kitchenham, 2008).

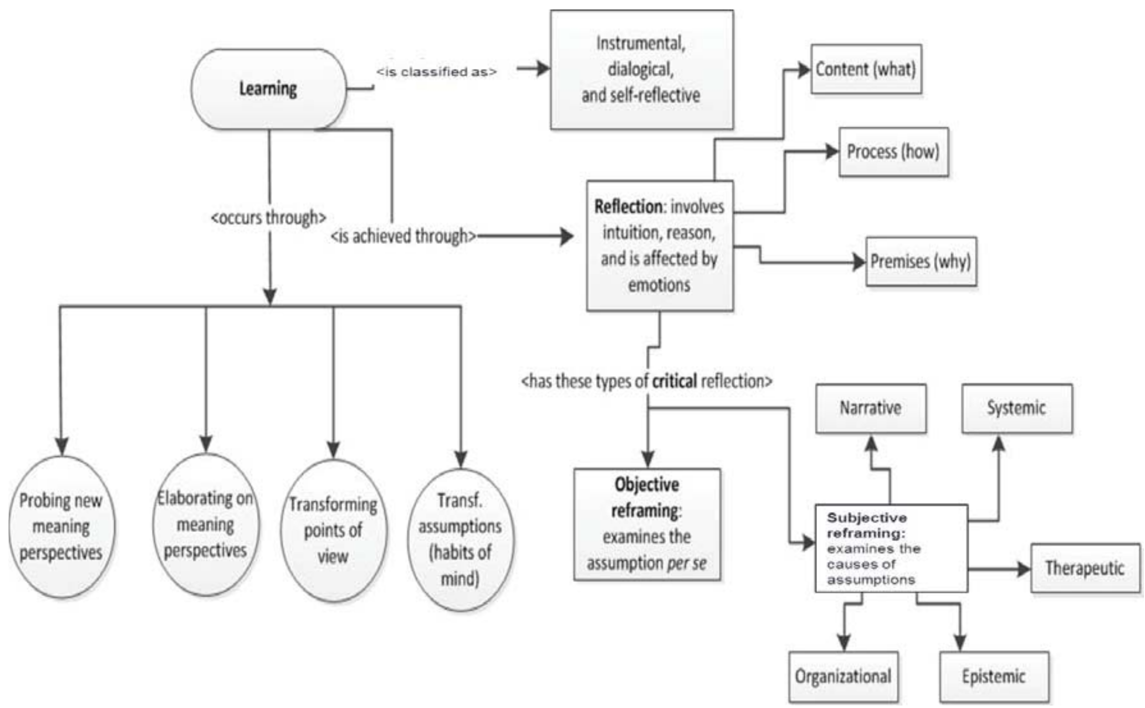

Figure 2.3 Ways of learning according to the theory of transformative learning

Mezirow (2000) argued that habits of mind may be transformed through critical reflection of our assumptions (e.g., questioning the veracity of our premises). This reflectivity process involves intuition and reasoning, which are conditioned by emotions (Mezirow, 2000). Transformations at the level of the habits of mind “may be epochal, a sudden, dramatic, reorienting insight, or incremental, involving a progressive series of transformations in related points of view that culminate in a transformation in habit of mind" (Mezirow, 2000, p. 21). Alternatively, we may also transform our points of view by probing those of others. At this level, imagination is crucial (Mezirow, 2000). This process incurs a critique of our previous assumptions of the phenomena that we are examining (Mezirow, 2000), be it "engineers," "engineering," "sustainability," or any other notion.

The theory identifies three categories of learning: instrumental, dialogic, and self-reflective (Mezirow, 1991; refer to upper right part of Figure 2.4). "Instrumental learning" is when the learners ask for the best ways to learn the knowledge (Kitchenham, 2008). "Dialogic learning" is when they need to know in what scenarios the knowledge takes place (Kitchenham, 2008). "Self-reflective" learning is when learners ask for reasons why they need the information (Kitchenham, 2008).

This theory argues that reflection is one of the main ways to learn. Mezirow (1991) stated that the core of our learning focuses on problem solving. We not only reflect on the problem content, but also on the steps to solve a problem (Mezirow, 1991). When we solve a problem, we reflect on our previous actions to find equivalences and disparities (Mezirow, 1991). The theory identifies three types of reflections: content reflection, process reflection, and premise reflection (Kitchenham, 2008). "Premise reflection" is "becoming aware of *why* we perceive, think, feel, or act as we do and of the reasons for and consequences of our possible habits [emphasis in original]" (Mezirow, 1991, p. 108). "Process reflection" examines "*how* we perform these functions of perceiving, thinking, feeling, or acting and an assessment of our efficacy in performing them [emphasis in original]" (Mezirow, 1991, p. 108). "Content reflection" is the reflection on "*what* we perceive, think, feel, or act upon [emphasis in original]" (Mezirow, 1991, p. 107).

In 1998, Mezirow revised his original work (Kitchenham, 2008) to add two aspects of critical reflection: objective reframing and subjective reframing (Kitchenham, 2008). "Objective reframing" examines the assumption per se, while "subjective reframing" examines the causes of the assumption (Kitchenham, 2008). Mezirow identified five types of subjective reframing that occur when you examine your own assumptions: narrative, systemic, therapeutic, organizational, and epistemological (Kitchenham, 2008; Mezirow, 2000). "Narrative" is the application of someone else's reflective insights to oneself; "systemic" is associated with Freire's *conscientization* (e.g., the process by which a human is conscious of his or her social condition or "oppression"); "therapeutic" is useful in psychological counseling; "organizational" is the self-reflection of one's own assumptions of the workplace; and "epistemic" examines one's own personal frames of reference: its causes, roots, and consequences (Kitchenham, 2008).

Scholars have argued that TTL has a strong Western, individual, and rationalized focus (Merriam & Ntseane, 2008). Merriam and Ntseane (2008) cited the following authors as providing good summaries of the problem:

> Research on perspective transformation has found that it is not a totally rational, cognitive process. Taylor (1997) summarized as follows: "Multiple studies refer to the significance of intuition (Brooks), affective learning (Clark, Scott, Sveinunggaard), extrarational influences (Vogelsang), and the guiding force of feelings (Hunter, Taylor)" (p. 48). Taylor (2000) recommended that more

research be conducted that explores the affective and relational qualities of transformational learning. (p. 185)

Mezirow (2000) acknowledged that his theory is limited by culture, society, history, and intersubjectivity. For example, community elders may still play a role to determine the causes and content validation of learning, as found in a study of village farmers in Senegal (Merriam & Ntseane, 2008).

In the field of engineering education, this theory has been applied in the following ways. Siddiqui (2014) developed a framework informed by transformative learning and other theories to examine the challenges of engineering education change. Thomas (2009) argued that reflective learning strategies based on transformative learning are a way to help individuals and communities to learn about sustainability and change their unsustainable practices. Berndt and Paterson (2010) used humanitarian engineering cases to help students reflect on the context and decisions pertaining to global engineering projects in the developing world. They were informed by the theory to help support the transformative learning process of their engineering students (Berndt and Paterson, 2010). Finally, Kristensen and Sørensen (2004) reported their approach to help engineering students learn the required course content by allowing them to assess each other's projects while at the same time reflecting on the content. Their approach was informed by transformative learning to help engineering students learn instrumental knowledge and practical knowledge.

I incorporated this theory in my research when I (a) designed the report guidelines that the students used to reflect on their project and teamwork, (b) designed reflective questions in my fieldnotes template (see Appendix I), (c) incorporated reflective questions about engineering and society in the course presentations, and (d) wrote the feedback for the students through statements and questions to help them think more about their design decisions.

2.5.3 Engineering education for social justice

This section is also relevant to both research questions because it describes a literature framework within engineering education that I used in my course content. Engineering education for social justice (EESJ) is a subfield within engineering education that attempts to answer two questions: (a) can engineering and social justice coexist together? and (b) how can we reconstruct an engineering education aligned to the values of social justice? (Baillie & Catalano, 2009; Schneider, 2010). Schneider (2010) argued that the theme of EESJ stems from research on engineering and social justice studies. For example, the works of Layton (1971) and Noble (1979) who uncovered the tensions between the values of engineering and those of social justice; and Slaton (2010) who researched the city planning of Chicago in the 1960s when tensions arose between programs that aimed for growth and modernization and those that cared for social justice (Schneider, 2010).

The theme within engineering education programs faces particular challenges because of the preconceptions and beliefs that people have about engineering (Lucena, Schneider, & Leydens, 2010) and the way that engineers and nations have defined engineers and engineering (Lucena & Schneider, 2008). For example, Lucena et al. (2010) argued that the following issues make more challenging the integration of social justice in engineering education: (a) the beliefs that development, modernization, and technological determinism bring progress to societies, (b) the view that communities are like "clients," (c) the belief that technologies can be universal, and (d) the complexities of cultures and politics that create tensions in the interactions between the engineers (or engineering students) and the communities they intend to serve (Lucena et al., 2010). To clarify some of the terms mentioned above, the authors defined "technological determinism" as the belief that technology alone has the power to transform societies and "development and modernization" as the belief that a socially engineered order based on science knowledge can bring progress and well-being to societies and that technological solutions can increase economic growth and welfare and reduce of dissatisfaction in the world (Lucena et al., 2010).

EESJ has been incorporated in engineering courses in the following ways. López, Sánchez, Cruz, and Fernández (2007) incorporated values of solidarity, labor rights, justice, and the environment in a PC architecture course. In the course, computer science students developed projects in the categories of "IBM, human rights, sustainable development and environment," "I/O devices for people with a disability," "Environmental-friendly PCs," among others (López, et al., p. 8). Kabo and Baillie (2009) developed a cross-disciplinary course about engineering and social justice which was taught in seminars with discussions and weekly assignments (Kabo & Baillie, 2009). The students had to reflect critically on the topics and develop a community-based project to examine an issue of engineering practice (Kabo & Baillie, 2009). Finally, Gillette, Lowham, and Haungs (2014) have incorporated EESJ-related courses such as "Culture, Society and Technology" (p. 124) in their Liberal Arts and Engineering Studies program at California Polytechnic State University, San Luis Obispo. Since the EESJ field is interdisciplinary, we can find instances of “social justice” in engineering education in other related fields.

I incorporated literature of the subfield of EESJ into the introductory course content. I narrowed my focus within EESJ to three main references that I thought could be practical in a pre-college course: Baillie & Catalano (2009); Bhatia & Smith (2008); Lucena et al. (2010); and Caroline Baillie’s work in Waste for Life (Baillie, Feinblatt, Thamae, & Berrington, 2010; Waste for Life, 2013). Table 2.1 lists in which lectures I incorporated this knowledge and how. Some of the lessons incorporated culturally relevant information as a way to relate to the students’ familiar contexts (the school and surrounding community).

Table 2.2 EESJ Literature in My Course Lessons

Class title	References relevant to EESJ	How EESJ sources were incorporated
Lesson 1.2: Engineering and Society	(1) An adaptation of Lucena, Schneider, and Leydens (2010). Chapter "*Why design for industry will not work as design for community*." (2) Example of an engineering design project: Solar power for Alampoondi, Tamil Nadu. Source: http://www.liteecases.com	(1) I adapted the chapter to design a reflective activity to help the students question what they would have done differently if they had been the engineering students who designed a solution for a village in Senegal. (2) I provided a summary of this LITEE lesson situated in the southern part of India to describe an engineering community project in an India context (because the students live in India).
Lesson 3.1: What is Sustainability?	N/A	I used photos of nomadic livelihoods in Tibet and asked students whether they think that those kinds of livelihoods are sustainable. I added an aerial map of a region of Tibet and asked the students how they thought that humans were impacting Tibet. I used videos relevant to the problem of waste management in India and the lifecycle of electronics. Sources: • http://www.youtube.com/watch?v=8AS9n8ioe4Y • http://www.youtube.com/watch?v=sW_7i6T_H78

Table 2.2 continued

Lesson 3.2: Examples of Sustainable Engineering Designs	Photos found on the Waste for Life blog (http://wasteforlife.org) and its Flickr account (https://www.flickr.com/photos/wasteforlife/) Schematics and videos about a hotpress used to transform plastics into sheets and forms that can be used to make useful things (http://wasteforlife.org/?page_id=442). Information about biodegradable materials from Baillie (2004) and Bhatia & Smith (2008). Video of the making of a light bulb out of a plastic bottle and chlorine. The idea was shared by Lindsey A. Nelson, https://www.youtube.com/watch?v=kHTD_RX3J2I.	I added the photos of designs made of "waste" to help the students see one of many forms of sustainable designs. I added photos about machinery used to recycle plastics. I presented a video about how plastic water bottles and chlorine can be used to make light bulbs. I presented photos of "sustainable designs" in several engineering fields. These designs were the following: • Biodegradable plastics • Composites made of organic materials • Biodegradable electronic circuit • Natural ventilation in buildings • Machinery to recycle plastics • Hotpress to melt plastics • Rechargable battery unit powered by solar energy I posited a question about "sustainable engineering" in the context of their school, specifically through photos of a paper recycling workshop held at the school: "How sustainable engineering relates to the processes of recycling paper?"

2.6 Relevance of my study in other frameworks

This section provides brief summaries of three learning theories to which this study's findings might be relevant: constructivist learning theory, experiential learning, and community-based service learning. In addition, it reviews the literature on multicultural engineering design teams because even though my students were Tibetans, my Western view ended up influencing them, as I will discuss in chapter 6. Therefore, I ended up being like another "team member" in their design experiences, even though I did not intend to be one. I can argue that the fact that they were influenced by multiple sources of knowledge and cultures is evidence that their design projects were like a multicultural design experience. Because of this reality, I provide the literature review below to indicate the relevance of my study in other frameworks.

2.6.1 Constructivist learning theory

Constructivist learning theory was developed by Jean Piaget and Lev Vygotsky (Goodman, 2010). This theory affirms that humans construct knowledge and meaning to life continuously through experiences and social interactions (Goodman, 2010). In a constructivist learning environment, the teacher is a facilitator (or guide) and learning is achieved through discovery and active interaction with the surroundings and others (Svinicki, 2004). A teacher may pose questions or a framework for an activity, but the learners have to figure out the solution through their own efforts. The learner thus constructs knowledge and reality from these interactions and experiences (Svinicki, 2004).

Constructivists believe that three sources of experience make each learner have a unique construct of the phenomena in question: the worldview of the learner, the environments in which he or she interacts, and the social interactions with others (Svinicki, 2004).

In this study, the design project undertaken by the students was a form of constructivist learning because I did not define the steps to design and implement a solution. Rather, I provided guidelines or a framework in which they had to identify a problem at the school site, possible design solutions, and materials and methods to implement the design. As I describe in Chapters 4 and 6, some of the students had difficulty identifying "problems" at the school site, probably because of cultural reasons or my Western way of identifying "problems." For those students, I provided some examples of "problems" that I perceived at the school site, and they figured out the rest (e.g., interviewing a person facing the problem, designing possible solutions, and so on) with the support of design feedback sessions. During their design process, the students attended feedback sessions, during which I provided my feedback in form of guidance or "coaching."

The students' design experiences can be categorized as constructivist forms of learning about engineering design and what engineers do because the design process was a socially constructed solution among them, which sometimes included different sources of knowledge and others' help, and the teacher served as a "guide." Therefore, the findings of my research can inform scholars who conduct educational research under a constructivist perspective or who research educational initiatives informed by constructivism.

2.6.2 Experiential learning

Experiential learning theory was developed by David A. Kolb, who was influenced by Dewey, Piaget, and Lewin (Kolb, 1984). His theory of learning has the following characteristics: (a) ideas are elements that are formed and re-formed through learning (i.e., learning is a process and not an outcome); (b) the process of learning is iterative; (c) reflection in the process of learning is needed to resolve conflicts between the new knowledge and previous knowledge (often times called "accommodation"); (d) learning is a process of adaptation to the world; (e) learning occurs through transactions between the person and the world around him or her (in other words learning is a process of negotiation); and (f) because knowledge is the outcome of transactions between the individual and social aspects of knowledge, learning is a process that socially constructs knowledge (Kolb, 1984).

Kolb's theory of learning can be categorized as constructivism because he views learning as formed and re-formed through experiences situated in a social context (Kolb, 1984). His model of learning has four iterative elements: concrete experience, phase of observations and reflections on the experience, formation of abstract concepts and generalizations, and testing the abstractions and generalizations in new situations (Kolb, 1984). He identified four learning styles, each with strengths and emphasis: assimilative, accommodative, convergent, and divergent (Kolb, 1984). Kolb (1984) also identified four learning environments for students: affective, symbolic, perceptual, and behavioral.

Experiential learning theory may relate to my students' design project in a few ways. When the students were experiencing design, they were in a phase similar to *concrete experience*. When the students communicated ideas to me and reflected on topics about how their cultural values were supporting their design experiences, they were aligned to the *phase of observations and reflections* of experiential learning. Finally, when some of the students tested their designs, that activity was meant to help them test their assumptions about their own designs. The testing activity can be aligned to the final two elements of the experiential learning theory (*forming abstractions and testing them in other situations in an attempt to form generalizations*). Even though I did not have enough time to help all teams pass through a "testing phase," among those who did it, Team 2 and 7 had the chance to observe the outcomes of a "testing activity" and based on their reflections, they redesigned to suit the needs of a "client." I did not have the time to help all teams pass through the testing phases, but those did (or attempted to) were to identify features that required redesign. (See Chapter 6 for more information about each team's design process.)

2.6.3 Community-based service learning

Service learning builds a bridge between the required academic learning in a curriculum and the needs of local communities and organizations (Oakes, Duffy, Jacobius, Linos, Lord, Schultz, & Smith, 2002). In a community service approach to engineering education, hands-on projects are situated in the context of a community in need for a technological solution, through which students can develop engineering skills and meet course requirements (Duffy, Barrington, Moeller, Barry, Kazmer, West, & Crespo, 2008). Oakes et al. (2002) argues that, through these experiences, engineering students develop insights on teamwork management, partner-engineer solution development, project management, and how their engineering skills can make an impact in local communities.

In this study, the teams' design projects were like a community service learning project. In teams, the students investigated a problem at the school site that could be "solved" through a "solution." They attempted to understand the problem by dialoguing with at least one person who was facing it. Then they brainstormed possible designs, researched possible materials and design configurations (mainly over the Internet and at the school's library), sought help from experts at the Vocational Training Center (VTC) and school teachers, and so on. Throughout this process they developed insights about the design process and teamwork relevant to engineering, especially in first-year engineering projects. In the end, they presented their project in front of their "customer," that is, the school community. The learning environment could be considered both a "first-year engineering" project and a "pre-college level engineering" project (because the age range of students was about the age of first-year engineering students). Therefore, I believe that the findings of this study can also inform those who apply service learning pedagogy in secondary school and first-year engineering education.

2.6.4 Multiculturality in students' engineering design experiences

This section provides a literature review background to support the importance of the second research question because I am examining the influence of cultures in relationship to engineering design and teamwork. In engineering education, there is a dearth of research on how engineering team members' cultural backgrounds influence design and team members' interactions and decisions. Furthermore, there is a dearth of research on how teachers' cultural backgrounds impact the design process of pre-college or college-level engineering student experiences. For engineering educators, these issues are important to understand in order to help engineering students develop skills that can be transferrable to the multicultural engineering workforce. These cases could also serve to show engineering students the realities of multicultural, diverse, or global teams and to reflect on possible actions to resolve conflicts or communicate more effectively. My research project is also an attempt to fill these gaps in literature.

Regarding engineering education interventions designed to help students develop communication skills relevant in a multicultural world, scholars have argued that college-level engineering programs should help students develop communication skills for them to make a transition to the globalized and multicultural engineering workforce (Downey, et al., 2006; Lohmann, Rollins, & Hoey, 2006; Lucena, Downey, Jesiek, & Elber, 2008). However, this need to help engineering students develop a multicultural or global competency comes with challenges to address. For example, Peña, Conesa, Hassan, and Ballester (2009) identified that there are linguistic barriers and different levels of formality between multinational engineering team members that create challenges to communicate effectively. Nevertheless, some activities like project-based learning have been found to help students develop communication skills like empathy (Rasoal, Danielsson, & Jungert, 2012). In addition, some pre-college engineering design courses have been found to help secondary school students develop communication skills that will be needed in college-level engineering teams (Matsuishi & Kitamura, 2006).

Regarding culture-related challenges in engineering-related multicultural teams,[19] Müller, Spang, and Ozcan (2009) found that in German-Swedish teams, there were differences in team orientation, level of formality, decision-making style, and decision-making processes between the two nationals. In a qualitative study of heavy construction engineering projects, Ochieng and Price (2009) found multi-dimensional factors that impact the effectiveness of multicultural engineering-related teams. They developed a framework with the following themes to help managers address cross-cultural issues on the field: leadership styles, team selection and composition, cross-cultural management of team development processes, cross-cultural communication, cross-cultural collectivism, cross-cultural trust, cross-cultural management, and cross-cultural uncertainty (Ochieng & Price, 2009).

Kivrak, Arslan, Tuncan, and Birgonul (2014) conducted a quantitative research on three cases of international construction projects. They found that "national culture plays a major role in knowledge sharing between individuals from different cultural backgrounds" (p. 648). They also found that the following barriers created challenges in cross-cultural international construction projects management: the ability to understand the language of the other person, level of trust, level of motivation, and hierarchical

[19] These research literatures are more relevant to civil or architectural engineering.

relationships and competitiveness (Kivrak, Arslan, Tuncan, & Birgonul, 2014). Finally, in a qualitative research on cross-cultural management in construction projects in Kenya and United Kingdom, Ochieng, Price, Ruan, Egbu, and Moore (2013) found that "effective project leaders should be able to understand the type of leadership style preferred by the multicultural project team so the project leader's authority is respected" (p. 316). Cultural empathy was a path for project leaders to be aware of their own characteristics and to use them selectively according to the context (Ochieng, et al., 2013). They emphasized that international construction teams "must understand the culture and environment they are working in" (p. 321).

Adding to the short literature review above, in the field of cross-cultural management (relevant in engineering practice as well), Hofstede's multidimensional cultural model has been widely referenced and implemented to examine the cross-cultural dynamics in management and in cross-cultural interactions (Hofstede, 2011; Minkov & Hofstede, 2011). This model consists of six dimensions to categorize national cultures in (a) power distance, (b) uncertainty avoidance, (c) individualism versus collectivism, (d) masculinity versus femininity, (e) long versus short term orientation, and (f) indulgence versus restraint (Hofstede, 2011).

Hofstede's framework has been applied in engineering education to understand cultural differences in engineering student teams (Mainwaring & Markowski, 1991). Jian and Sandnes (2009) applied it to understand the differences between Norwegian and Taiwanese engineering students and they found that "Norwegian students may rate their own abilities higher than Taiwanese students since the Norwegians have to be self-promoting (individual) versus the Taiwanese who are more humble and must receive acclaim through others (collectivist)" (p. 994). Hazzan and Dubinsky (2005) applied Hofstede's framework to understand if the values and practices of extreme programming (XP) are aligned to the Israeli culture in the software industry. They found out that XP values of communication, courage, and feedback fit in the tight Israeli culture; however, some of the XP practices such as refactoring and test-driven development are resisted by Israeli programmers because they go against the improvisational value of the Israeli software industry (Hazzan & Dubinsky, 2005).

In the next section, I review the literature on sustainability education because one of the components of my course design was sustainability.

2.6.5 Research on sustainability education

Because of the well-known climate change impacts on Earth (Dessler, 2011), global efforts are being placed on sustainability education to develop not just a sustainability competency in engineering students, but a sense of responsibility to our planet. To join those efforts, I included a sustainability component in my course content and design projects. The section summarizes other projects like mine that had, as a goal, to help students develop their sustainability knowledge or competency. The section is also relevant to the first research question because I incorporated sustainability in the course content and design project and the first research question examines how I developed and taught the course.

Relevant to design activities for engineering students, Jollands and Parthasarathy (2013) developed a project-based learning activity for engineering students in which they incorporated sustainability. In the activity, the students developed justifications for choosing the best design processes not just based on return-of-investment (Jollands & Parthasarathy, 2013). They also defined criteria based on sustainability principles and researched on literature to identify the environmental, social, and economic impact of a design, among other tasks (Jollands & Parthasarathy, 2013).

Relevant to sustainability curriculum development, Lau (2007) incorporated "green design" (or the practice of engineering inclusive of natural systems) principles in a first-year engineering program. In this type of project, the focus is on materials selection (e.g., biodegradable) and life-cycle assessment (Lau, 2007). The author (Lau, 2007) included videos and discussions in class to help students see the impact of green design in society.

Also relevant to engineering curriculum development, Kevern (2011) reported on a graduate-level civil engineering course on "Green Building and Sustainable Infrastructure" (p. 111). The Leadership in Energy and Environmental Design (LEED) green rating system was used to introduce green building technologies (Kevern, 2011). They also included content in "green rating systems, hazardous waste, global warming, storm-water management, low-impact development, urban heat island, and life-cycle analysis" (Kevern, 2011, p. 111).

Finally, relevant to approaches of teaching sustainability, Aurandt and Buter (2011) presented case studies of three courses dedicated to discuss topics of sustainable engineering in different universities: "Green Industrial Organic Chemistry," "Environmentally Conscious Design and Manufacturing," and "Sustainable Engineering" (p. 102). From the first course, they identified that "courses can be adapted to integrate sustainability by changing the examples and exercises used within the course" (Aurandt & Buter, 2011, p. 105). From the second course, they found that "topics presented were applicable to students' co-op experiences and their future employment" (Aurandt & Buter, 2011, p. 105). From the third course, they found that the knowledge acquired about the following topics was used in other courses and employment: "global resource reserves, sustainable growth and development, design for the environment (DfE), and LCA [life-cycle assessment]" (Aurandt & Buter, 2011, p. 105).

In the design projects, I made it compulsory for the students to reuse materials and use locally available biodegradable materials as much as possible. In addition, in my PowerPoint presentations, I added information about sustainable energy technologies, how engineers are implementing sustainability principles in their designs (e.g., examples of projects), energy consumption information, and the impact of waste generated by contemporary industrialized societies in the world and in particular in India (e.g., the case of e-waste recycling laborers in New Delhi).

2.7 Summary of the course and design project

Figure 2.4 summarizes the components of my introductory engineering course and design project. They were informed by the theory of transformative learning, EESJ, and culturally responsive teaching. I was inspired by the Socially Engaged Buddhist movements and *Mahāyāna* Buddhism. I used introductory engineering references about engineering design, manufacturing engineering, structural engineering, sustainability, sustainable design, and sustainable energy technologies.

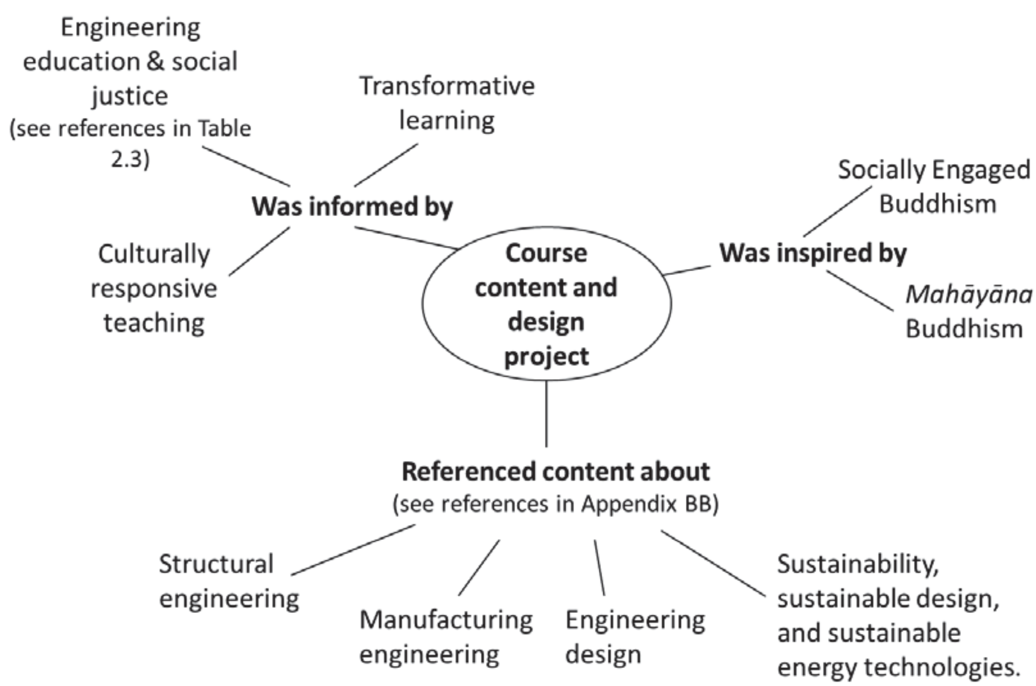

Figure 2.4 Concept map of the introductory engineering course

CHAPTER 3. RESEARCH AND DATA ANALYSIS METHODS

3.1 Introduction

My doctoral research was a case study (Yin, 2009) of the development and implementation of an introductory engineering course for pre-college Tibetan students, using a culturally responsive approach to teaching (Gay, 2000). In addition, it sought to understand how Tibetan culture and Buddhism influenced the design process and teamwork of the students, because the course required them to investigate a problem at the school site and design a solution to it. The aim of the design project was to provide students with the experience of engineering design, just like that of a first-year engineering student or a pre-college student in an engineering program. The design project had a focus on sustainability and sustainable design inspired by the work of Waste for Life (2013). It also had a transformative learning (Mezirow, 1991) component, because it sought to empower students to take action on the problems that they identified at the school site.

My two research questions were as follows:

1. What are the processes to develop and implement a pre-college culturally responsive introductory engineering course?
2. How do Tibetan culture and Buddhism influence the engineering design and teamwork of Tibetan students in the pre-college introductory engineering course taught at Tibetan Children's Village School of Selakui?

As I explained in Chapters 1 and 2, there are is dearth of scholarly literature about culturally responsive ways to teach engineering to diverse populations, even more to secondary school students. In addition, there is a dearth of research on how team members' cultural backgrounds impact engineering design and teamwork; in other words, research on engineering design teams' experiences from a multicultural perspective to inform engineering education. Therefore, my research questions attempt to fill a gap in the engineering education field, and also more broadly in culturally responsive pedagogy.

I collected qualitative data (Patton, 2002; Strauss & Corbin, 1998) using ethnographic research methods (Fetterman, 2010; Wolcott, 2008). My main sources of data were:

- Fieldnotes
- Students' design progress reports (per team)
- Students' pre- and post-course questionnaires (individually)
- Photographs and videos of (a) students' final project presentations, (b) feedback sessions in class, and (c) lectures
- Interviews with Tibetan teachers, engineers, and a school administrator

The characteristics of qualitative research are: (a) it explores a central phenomenon that is not well understood, (b) it justifies the importance of the research problem, (c) it does not provide predictions (as could be the case with mixed-methods or quantitative research), (d) it can involve a biased point of view, and (e) it may pose sub-questions to the main research questions to seek a deeper understanding of the central phenomenon (Creswell, 2008). As explained in Chapter 2, because of the dearth of literature in culturally responsive ways to teaching to diverse populations, I decided to use qualitative research methods to explore a central phenomenon (an introductory experience of engineering in a pre-college introductory engineering course for an ethnic minority group) that has not been explored substantially by scholars in the engineering education field. In addition, I also thought that qualitative research methods suited this research study because of my postcolonial and Buddhist informed perspective when interpreting the data.

This chapter is divided into the following sections: case study, ethnographic research methods, data collected, methodology, and grounded theory data analysis methods.

3.2 Case study

A case study is a type of research study design that informs the way that researchers analyze data. According to Yin (2009), case study design considers five components: (a) research question, (b) propositions (if any), (c) unit(s) of analysis, (d) a connection between the data and the propositions (e.g., pattern matching, explanation building, logic model, and cross-case synthesis), and (e) criteria for interpreting the findings (if statistical methods are used). The research questions[20] determine the research methods of a study (Yin, 2009). The proposition(s)[21] are questions that are posited to focus data gathering in order to obtain relevant evidence (Yin, 2009). The unit of analysis[22] is the most specific phenomena within a case study to be analyzed (Yin, 2009). The way data and propositions are connected[23] are through the methods used on the units of analysis (Yin, 2009). Finally, the criteria for interpreting our findings are relevant in statistical research methods[24] and include the level at which a number is considered to be statistical significant (Yin, 2009).

A case study investigates a present-time phenomenon in depth and in a real-life context. The phenomenon in this single case study is the introductory experience of engineering in a pre-college introductory engineering course for an ethnic minority group. To understand a phenomenon that is not clear due to lack of research, I depended on multiple sources of evidence (see 3.5 for a list of data collected). All these data helped me to triangulate the research findings to improve their credibility (Yin, 2009).

I have determined this is an exploratory case study (Yin, 2009) because there is a dearth of research on (a) science, technology, engineering, and mathematics (STEM) education for ethnic minorities who are immigrants or refugees outside the United States

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[20] I already discussed the research questions in section 3.1 and why I decided for qualitative research methods.

[21] There were no propositions in this study, although while I was in the field, I investigated other subquestions as I was learning about the school and students. Yin (2009) stated that an exploratory case study may not have propositions, but should have a purpose. See section 1.1 for a discussion about the purpose of the study.

[22] I will discuss the units of analysis of my study later in this section.

[23] As explained in footnote 20, there are not propositions in this study. I will discuss the way that the data and my research questions were linked later in this section.

[24] Since my research does not involve statistical methods of analysis, this component is not included.

and (b) how a group's culture and specific circumstances (e.g., host country, Western influence, and socio-historical factors) impact their practice or learning of engineering.

The units of analysis of a single case study can be holistic or embedded. A holistic design takes a global perspective of the phenomenon being studied, while the embedded design explores more than one unit of analysis (Yin, 2009). This case study involved embedded units of analysis in the form of eight student team projects. Within these embedded units, I reviewed each team's design process and teamwork dynamics, using their progress reports and fieldnotes as my main data sources.

I determined that an embedded design would be more suitable than another form because I needed to analyze each team separately. I decided to analyze each team and not each student because during my fieldwork I observed that the phenomenon we call "engineering" is multidimensional and its interpretation depends on one's perspective. After observing my students, I took the perspective of engineering as design *and* teamwork, the center being teamwork. Other scholars in engineering education share a similar perspective. For example, Catalano (2012) developed a framework based on contemplative pedagogy to support students' teamwork experiences. Because I took this perspective, each team is a unit of analysis.

Figure 3.1 represents my case study design. The outer rectangle represents the context of the research study (Tibetan Children's Village School of Selakui). The first inner rectangle represents the case (introductory engineering course). The internal rectangle with the dashed line represents the units of analysis of the case study (eight design projects). The list of data sources is per case and per unit of analysis, respectively, in both rectangles.

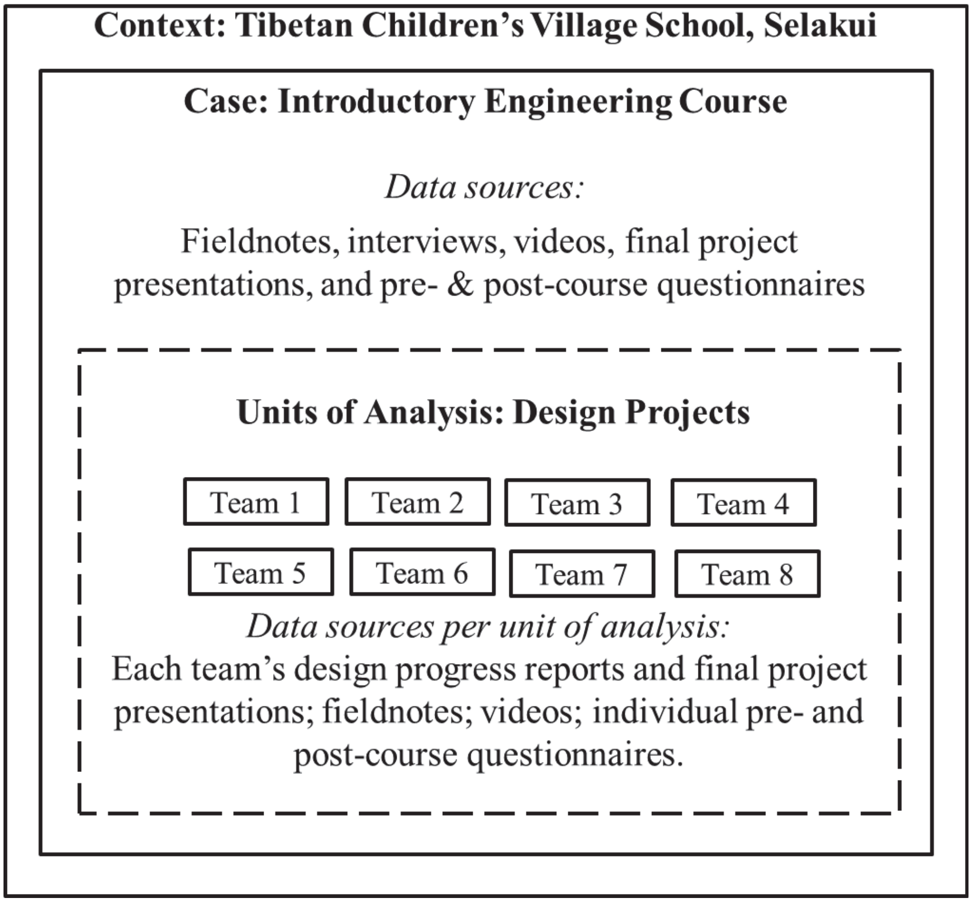

Figure 3.1 Embedded units of analysis
Note. Modelled after Yin's (2009, p. 46) example taken from COSMOS Corporation's "Basic Types of Designs for Case Studies."

I used ethnographic research methods to collect the data for my study. In the following section, I provided a summary of what an ethnographic research study is and its research methods.

3.3 Research methodology

A "research methodology" differs from one's "research methods." A "methodology" is the way the research is conducted; or the philosophy that gives us a reason why certain research-related actions may result into answering one's research questions. The "research methods" are the "tools" used to collect research data. In qualitative research, the methodology is selected based on the theoretical lens, critical perspective, biases, and research context. The methodology is important because it determines the questions, research instruments, and methods (procedures) to gather data (Smith, 1999).

In my first year of doctoral studies, I learned about decolonizing research methodologies (Smith, 1999). I saw a connection between my perspective and Smith's (1999) view of how research should proceed in Indigenous communities; therefore, I used her methodology as a guide to design my research study and to conduct my research in Tibetan communities in exile. I believe that my perspective is largely based on my sociocultural and historical backgrounds. I was born and raised in Puerto Rico. My mother's side of the family came from the countryside of Arecibo and Utuado (two municipalities of Puerto Rico). Up to 1960, my maternal relatives were peasants (*jíbaros,* as they are called in Puerto Rico). In the late 1960s, they moved to the capital where some of them started postsecondary education.

I was raised in a family of mixed political ideologies and mixed religious beliefs. In my early childhood, my father adhered to a pro-statehood ideology. My mother was "neutral" to local politics, and the rest of my maternal relatives were either procommonwealth or pro-independence. My immediate family adopted diverse religious beliefs, and I heard my father express atheist and pro-scientific thought as well. My grandmother told me stories of her elementary education under colonial Puerto Rico, at which time schools only taught in English (in the early 1900s), in an attempt to Americanize the Puerto Ricans. She shared how difficult it was for Puerto Ricans of that era to learn school subjects in English, especially mathematics. My grandparents also told me about their ways of life in the countryside, which they valued more than the ways of life in the capital.

Even though I was born and raised in urban areas, I always felt uncomfortable with what I saw as the insensitive, competitive, and violent aspects of "modern" society; therefore, perhaps I unconsciously decided to not integrate completely into what I believed to be a detrimental environment. I was critical of the violence that I observed throughout my life in Puerto Rico, especially forms of violence and micro-aggressions that obstructed others' freedom of choice, individuality, and others' identities.

That was the reality in which I grew up. I was impacted by the ideological "battle" in Puerto Rico, as were the rest of the Puerto Ricans. I was influenced by many spiritual traditions, and in the end I had to make up my mind and choose. Because of my experiences in Puerto Rico, and subsequent experiences in the United States, I have chosen to keep my sociocultural identities of Puerto Rican *jíbaro*, American, and Buddhist. This may sound like a paradox, but I can attest to the fact that these seemingly disparate identities can make peace with each other.

Because of my experiences in Puerto Rico and my internalization that I was "nobody" because I have a female body, and that my family members were "nobodies" as well, I rarely verbalized my thoughts and opinions. Even today, although I can think critically in my mind, it is very difficult for me to verbalize my thoughts and speak my opinions. From what others told me and what I observed in “modern” society, I internalized the perception that my way of thinking, interests, goals, values, beliefs, character, and personality were “wrong” and that I “needed to change” in order to “fit” into the “modern” world. Sometimes I was pressured to verbalize my thoughts, and sometimes I was pressured to keep silence because I was a “nobody.” I believe that there could have been a cultural component to this issue as well: I valued silence as a method of reflection, I valued politeness, and therefore verbalizing my intellectual mind was not one of my goals.

I became interested in Buddhism while in Puerto Rico. I believe the reasons why are very complex, but I will summarize them here. I wanted to cope with the effects of what I experienced or observed in my childhood, schools, family, neighborhoods, universities, public transportation, and streets while in Puerto Rico. I wanted to make sense to the turmoil of having been born and raised in a U.S. territory (read *colony*). I wanted to belong to a spiritual community that could accept me as I am without forcing me (directly or indirectly) to change my values to become “modern” or to believe in a God because my deepest belief about the existence of God are aligned to agnosticism, even though I never verbalized them to be polite or because of fear of being shunned by society. Therefore, because of who I am and what I believe, I wanted to find an inclusive and welcoming space while I was in Puerto Rico.

The turning points for me to become a Buddhist were my experiences as a college student in Puerto Rico and the observations of the contrasts between the scientific society, the rich, the poor, and working class people in Lima, Peru, while I was in an internship abroad in a radio observatory in 2007. When I came back from that internship, I began to see that Puerto Rico was an intersection of Latin America and the United States and that somehow I did not fit *entirely* either in Latin America or in Puerto Rico. It was when I came back from that internship in Peru when I decided to formally convert to Buddhism. I chose Tibetan Buddhism because one of the centers was more accessible for me (as I did not have a car), they had a program to serve food for low-income people every week, and I perceived that the colorful Tibetan Buddhist tradition connected to my Caribbean cultural background.

Because I was very grateful of having found *home* in Buddhism, I wanted to give back to my Buddhist community and Buddhist Tibetans in India by the means of my doctoral research project. When I went to India and I started conducting my research fieldwork, I noticed many similarities between Tibetans in exile in India and the politics, cultural identity development, and nationalist sentiment of island-born Puerto Ricans. These similarities that I noticed made me to face while in India what I did not want to face in the United States: My experiences in Puerto Rico and my "fleeing" to the United States.

In the data analysis phase, I looked deeply into my intellectual mind (or "ego") to determine what I really believed in to continue with my thesis and graduate. I had to acknowledge my identities and my way of thinking to situate my intellectual mind in a theoretical framework. After reflecting on the consequences of embracing my intellectual mind and on my need to continue with my thesis, I recognized that I would lose acquaintances and relatives because I would embrace a part of me that is not aligned with them. Therefore, because of these deep tensions, my data analysis phase was the most difficult phase of my research study.

Because of these sociocultural and historical reasons, I believed that the discourses of Indigenous peoples (introduced by Linda Tuhiwai Smith's research methodology) and their experiences with colonialism(s), nationalism(s), and modernities are familiar to my own experiences and to *some* Puerto Ricans who were (or are) peasants or who do not fit entirely in the "modern" society and the national culture, as defined by some people of power in Puerto Rico.

Smith (1999) identified four priorities of Indigenous communities: survival, recovery, development, and self-determination. Smith (1999) also identified 25 major themes of research projects in Indigenous communities. She defined the category "discovering" to refer to projects that connect science and technology with the ways of knowing (or learning) of a particular culture (Smith, 1999). I believe that this category best suits my project because it involves understanding the connection between engineering and Tibetan culture to facilitate the goals of culturally responsive education in Tibetan society in exile.

I do not consider myself to be a curriculum expert, but as a teacher-researcher community partner who is learning how to respectfully teach Tibetans in exile in India. Therefore, to implement Smith's (1999) framework in the curriculum development, before I started the course I met with Tibetan teachers and administrators to solicit their feedback about the course content and project and to learn strategies that align them with the students' needs, school missions, and class level. I attempted to develop an introductory engineering course that respects the culture of the local people by (a) reinforcing the values of altruism in Tibetan culture through a community service project and (b) connecting engineering to their familiar school context, surroundings, and livelihoods.

I implemented Smith's (1999) framework in my research as follows. Because Tibetans in India live in a sensitive political condition (the majority are refugees), it was imperative that I approached the community members with respect, patience, and concern for their privacy. I accomplished this by (a) meeting each potential interviewee several times to help him or her build trust in me, (b) taking time before an interview to help the informant understand what I meant by "engineering" (especially when interviewing Tibetans who were monastics or elders), (c) taking extra measures to protect the privacy of those who wanted to share their views but who were in a more vulnerable (powerless) position within the society, and (d) approaching a *Lama*[25] of the community to seek a blessing for the research project.

After spending time at TCV Selakui, I realized that my vision for the course, influenced by Smith's (1999) work, was aligned with TCV's community service, culturally responsive, and experiential learning approaches in after-school activities. Therefore, even though I faced personal limitations (e.g., time and resources), with the help of the school teachers and administrators, I was able to present my students with an introductory engineering course and design project inclusive of their ways of being and the altruism that is valued in Tibetan culture.

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[25] A *Lama* is an honorific title conferred to a Tibetan Buddhist teacher who has achieved a high level of Buddhist practice within a Tibetan Buddhist linage through a rigorous Buddhist education. The title confers the authority to teach Tibetan Buddhism to others.

3.4 Research methods

I used ethnographic research methods to gather and describe data, and interpret the phenomena. Ethnography seeks to understand the shared patterns of a culture of a group of people: beliefs, behaviors, customs, way of life, and language (Wolcott, 2008). Ethnographers gather artifacts and evidence (e.g., stories, rituals, myths, and cultural themes) as data to be examined. A "culture" consists of the patterns of daily living in a group of people observed (or attributed) by a researcher as he or she engages in research fieldwork (Wolcott, 2008). The ethnographer typically spends time in the setting conducting interviews, observing, and collecting documents about the group to understand its culture-sharing patterns (Wolcott, 2008).

The fieldwork period was from April 1, 2012, to December 23, 2012. I stayed at Thosamling Institute (http://www.thosamling.com), a retreat center located in Dharamsala (a town in the state of Himachal Pradesh) from April to May 2012. The time in this retreat center was necessary to acclimate to the environment and culture of the northern region of India, as well as the Tibetan communities in India. In June 2012, I moved to Selakui town, Dehradun district, in the state of Uttarakhand, India. I stayed in TCV Selakui from June to mid-October 2012. I returned to Dharamsala in mid-October and stayed there until December 25, 2012.

I was a participant observer (Fetterman, 2010) because I stayed in the school community before and during my intervention, participated in some of the community activities, taught the course, and helped the students. Each day, I recorded my observations, reflections, next research fieldwork tasks, and questions to ask—first in notebooks and then in digital form by the end of the day (or weekend). My reflections were guided by a reflective questions template (Appendix I). In the next subsections I detail my recruiting, transcribing, record keeping, and data collection processes.

3.4.1 Research instruments

My research instruments were my reflective journal template, class fieldnotes guide, semi-structured interview guides, pre- and post-course questionnaires, template to research Tibetan ways of problem solving, and design progress report guidelines. I designed all of these instruments. Table 3.1 lists each instrument and the Appendix in which it can be found.

Table 3.1 Research Instruments

Instrument Title	Appendix Number
Reflective journal template	I
Class fieldnotes guide	J
Semi-structured interview guide for Tibetan educators, school administrators; curriculum, technical, or cultural experts	K-M
Revision at the field: Semi-structured interview guide for Tibetan engineers	N
Pre-course questionnaire	P
Post-course questionnaire	Q
Design progress report guidelines	A-D
Templates to research Tibetan ways of problem solving	O

Here, I explain how I designed each research instrument. For the reflective journal template (Appendix I), I started with general questions to remind me of the activities I observed and the people I met. The second section had questions to help me think on how what I learned about the school or students is related to Tibetan culture and Buddhism. The third section had self-reflective questions informed by the TTL to help me reflect on the events I observed or experienced; generate a plan of action for the next day; and write recommendations (if any) to teachers upon what I was learning on the field. I focused on the *self-reflective* category of learning (Mezirow, 1991) and the questions asked about (a) the assumptions that I revised about a phenomena learned on the field and pertaining to the research questions (*content and premise reflection*); and (b) a plan of action for the next day based on what I was learning on the field (process reflection).

For the class fieldnotes guide (Appendix J), just like the reflective journal template, I started with reflective questions that implemented the TTL in my context. The questions were aimed to record my observations on the students' reactions to my lectures or a topic (premise and process reflection). The second section had two reflective questions aimed to map to culturally responsive pedagogy. Essentially, they were also informed by TTL because I asked about how their culture and Buddhism were reflected in their responses in class (if any).

For the semi-structured interview guides for teachers, engineers, and others (Appendix K and L), I defined general demographics questions in the first section. The second section had questions about the teachers' challenges to teach STEM topics to Tibetans, their recommendations, and a question about how the person became a teacher in Tibetan schools. All questions were slightly modified depending on the context of the individual (e.g., his or her teaching subjects). The second section asked some questions about a Tibetan educational policy in exile that appeared online.[26] The third and fourth sections were aimed to ask the teachers about what they thought about the course content in order to learn how to adapt the course to the needs of the students. The fifth section

[26] My participants thought that the policy belong to the elementary education level only.

asked the teacher his or her feedback on the course project. The sixth section probed about the relationship between their cultural background, Buddhism, and learning STEM topics. The seventh section asked about Tibetan mathematics.[27] Finally, the eighth section was targeted to school administrators and I eventually omitted it entirely from my interviews because it was no longer relevant to the context of TCV Selakui.

In the field, I found I needed to revise the interview guide for engineers (Appendix N). The structure of this revised document is as follows. The first section had general demographic questions. The second section had questions about the engineers' knowledge and experience about engineering when they were in high school; and why they chose engineering. The third section asked about the engineers' challenges while they were in college. The fourth section was the most important to answering my research questions because it asked questions about how the engineers thought that their Buddhist cultural values and beliefs have been relevant in their engineering work. The fifth section was aimed to learn if they have attempted to teach engineering-related knowledge in informal learning contexts; and other questions about access and enrollment to engineering colleges. The sixth section is an extension of the fourth.[28] The final section asked them for their final recommendations to Westerners teaching STEM topics to Tibetans in exile.

The "Template to research Tibetan ways of solving a problem" (Appendix O) had three sections. The first section had reflective questions about what was the tool, artifact, or technique about. The second section had questions to help me reflect on how Tibetan

[27] My participants did not know what the educational policy was referring to.
[28] It seems that due to lack of time, I wrote down the questions without organizing them well.

culture and Buddhism were connected to the tool or artifact. The third section had questions to help me catalogue the media associated to the tool or artifact.

For the design progress report guidelines (Appendixes A to C), I mapped each guideline with a phase of the four-phased Buddhist-based model that I proposed to help the students understand the design cycle while at the same time being inclusive of their cultural background (see Appendix CC). Appendix D has a template to help students design the electronic presentations that were presented at the school auditorium. A teacher recommended I explicitly explain to the students how what they are doing is like the work of engineers; so, in the first guideline (Appendix A) and in the first box, I addressed the questions "why I am asking you to submit progress reports?," "how this work relates to the real work of an engineer?," and "how this work relates to the real work of an engineering *student*?" In the second and third guideline (Appendix B and C) I focused to answer only the question "how this work relates to the real work of an engineer?" Addressing these questions was a type of "instrumental learning" (Mezirow, 1991) about the work of engineers.

The design project report guidelines had slight differences in their structures because I modified them while I was learning on the field,[29] but essentially the idea was to (a) make explicit the instructions to answer the questions; (b) ask questions to help them reflect on their design decisions and how their Tibetan and Buddhist cultural background were relevant in their teamwork and design experiences; and (c) provide an example of a possible progress report responses to serve as guidelines. Recall that in TTL,

[29] See Appendix AA to learn more about what those changes were specifically.

learning is achieved through reflection; therefore, the reflective questions were “tools” to help the students learn about design and about how their values impact design and teamwork through their reflections and dialogues with me in feedback sessions.

For the pre-course questionnaire (Appendix P), first I presented demographics questions. Second, I asked the students about their intention to pursue a STEM career. Third, I started the “Main questions” sections by asking reflective questions about engineering, engineers, sustainably, and sustainable engineering; then, I asked about where they thought that their knowledge of engineering came from; if they have met an engineer; and the last section “Tibetan identity” was aimed to understand better from their perspective and not from my previous Orientalist (Said, 1994) perspective, what do they think it means to be a Tibetan and what makes a person a Tibetan (among other questions).

Finally, for the post-course questionnaire (Appendix Q), the first section asked the students to checkmark one of the statements about the influence of the course on their thoughts about studying engineering. In addition, it asked other questions about what branch of engineering they studied. The second section asked about their understanding of engineering, engineers, and sustainability from their perspective after having taken the course. The third section (there was a numbering error in the questionnaire) asked about their future dreams in STEM. I wanted to add this question as an inspirational and reflective component, aligned to TTL’s reflective learning focus. The fourth section asked questions to gather their course feedback.

3.4.2 Obtaining access to TCV Selakui

My first point of access to the research was the Norbulingka Institute in Dharamsala. I received a letter of permission to conduct research via the Tibetan Mongolian Buddhist Cultural Center in Bloomington, Indiana (with the help of Arjia Rinpoche and his secretary, Mary Pattison). When I arrived in Dharamsala, I met with an officer at Norbulingka Institute on April 10, 2012. After discussing the project, we realized that the Institute was not the right education setting for the study because the students did not have the required English proficiency and were mostly interested in the arts. The officer tried to contact Tibetan Children's Village at Upper Dharamsala without success; however, he was able to contact the director of Kunpan Cultural School, a transit school for Tibetans located in the town of Sidhpur. Transit schools are Tibetan schools in India where recently arrived adult Tibetans obtain vocational education.

During my second meeting with the Norbulingka officer, I met with the school administrator of Kunpan Cultural School. I visited the school on April 28, 2012, to present my project information to the students. After learning more about the students and the education setting, I realized that the type of course I was offering did not suit their background and needs (they were more interested in computer and Internet literacy). During my search for another site for this research study, I visited the Department of Education (DOE) of the Tibetan Government in Exile (TGIE) and the Jamyang Choeling Nunnery in late April 2012. The DOE suggested that I talk to officers of the Sambhota Schools system, but I could not find their offices. An administrator of the Jamyang Choeling Nunnery explained that it would be impossible for me to teach there because the students (all nuns) have the priority to acquire the same skills and level of Buddhist philosophy and debate as the monks; therefore, their priorities and interests are not to learn about engineering.

My last option was to try to connect with Tibetan Children's Village by myself. In fact, my original proposal to the National Science Foundation (NSF) for the Graduate Research Fellowship was to offer the course in a Tibetan Children's Village. I called the main offices of Tibetan Children's Village Selakui and scheduled an appointment with the education director (Ms. Sonam Dholkar Samkhar-la) to discuss the project. After our meeting, she discussed the project with the principal of TCV Selakui (Mr. Duke Tsering-la). After their discussion, she called me to tell me that I should meet with him personally at Selakui (in the state of Uttarakhand). On May 3, 2012, I traveled to Uttarakhand to meet with the school administrators of TCV Selakui. The next day, I presented my project information to the high school Tibetan students who expressed an interest in taking the course. Because the students were sufficiently proficient in English and had a basic science background, we agreed that the school was the proper one to teach the course. The school administration then agreed that the best time to teach it was in September, as they were busy with mid-year exams during the summer.

I returned to Dharamsala to work on the institutional review board (IRB) revision and course curriculum. On June 7, 2012, I moved to TCV Selakui. With the school's help, I recruited participants (e.g., Tibetan Buddhist monastics, Tibetan engineers, and teachers) and students. On August 6, 2012, interested students signed the consent form and completed a pre-course questionnaire about their engineering understanding. I interviewed participants, worked on the curriculum, engaged in some activities at the school, and took time to learn about the school community and surroundings until the start of the course on September 3, 2012.

3.4.3 Fieldwork at TCV Selakui

During my intervention, I often had to email colleagues at Purdue University, look for information to add in the course content, and maintain communications with my adviser, Dr. Alice L. Pawley. For these activities, I used a mobile Internet service for personal computers. My laptop had a high capacity battery, which was helpful because there were frequent power outages.

I held meetings with school administrators almost every weekday. In early August, the principal and I agreed that it would be best to hand out the consent forms and pre-course questionnaire as soon as possible before the students became busy with other course assignments. On that same day, he met with the class 10+1 and 10+2 students[30] to ask which ones were still interested in taking the course. As the principal stated, some students expressed concern about how they would benefit from the course. A teacher also echoed this concern; these concerns prompted me to add a slide to each presentation that answered the question "How this information might benefit you?"

I had to be mindful that teachers were always busy, especially during school events. I had to adapt to their schedules, be patient about their response time, and be careful not to bother them too often, which could be challenging as my time to conduct research was limited. In addition, I had to be careful about my methods of

[30] Equivalent to 11th and 12th graders.

communication. Therefore, I used not only verbal but also written communication, to ensure that the other party (e.g., secretary, principal, headmaster, or worker) understood my needs.

The principal informed me that the entire school (e.g., middle school students, teachers, and staff members) would be invited to the final presentations, as one of their cultural ways to share good news to the entire school community. Thus, for the final project presentations, I booked and arranged the school auditorium with the help of a staff member and several students. One week after their final presentations, I gave the students certificates of completion at the morning assembly (the moment when the students gather in the morning before starting their class). Based on the principal's recommendation, I wrote introduction and closing speeches for the final project presentations and the certificate distribution. The TCV Schools system required me to submit a short essay describing my experiences in the school before leaving the site.

3.4.4 Recruiting participants

I used purposeful opportunistic sampling and snowball sampling to select my interviewees and students. Posting flyers on bulletin boards was not an effective recruiting method; instead, I relied on face-to-face conversations and meetings to explain the study to potential participants. School administrators and teachers helped me to identify potential interviewees (e.g., Tibetan Buddhist monastics, Tibetan engineers, and teachers). School administrators helped me to identify potential students and to remind them of when and where they needed to meet to sign the consent forms and pre-course questionnaires. Adult students (18 and up) signed a different consent form (Appendix S) than did minors (Appendix T). For minor students (16 or 17 years), the principal signed all of their consent forms as the legal guardian (Appendix U), because in Tibetan society in exile in India, it is widely understood that the principal of a TCV school is fully accountable for the students while they are in session (in a semester). The following other parties also signed consent forms: teacher assistant (Appendix X); teacher, school administrator, cultural, or technical expert (Appendix V); and non-Tibetan community member (Appendix W).

Table 3.2 shows the number of participants recruited per category, their eligibility, and their compensation.

Table 3.2 Participants' Categories, Eligibility, and Compensation

Number of participants recruited	Category, Eligibility, and Compensation
14	A. Tibetan teacher • Must be Tibetans. Can be from a subsequent generation of Tibetans in India. • Any gender • Must be 18 or over • Must understand English • At least 1 year teaching in a Tibetan school in India • Preferably has taught science, technology, engineering, or mathematics courses to Tibetans (high school level) • Compensation for the participant: $10 one time
	B. Tibetan school administrator/director • Must be Tibetans. Can be from a subsequent generation of Tibetans in India. • Any gender • Must be 18 or over • Must understand English • At least 1 year designing curricula for courses taught to Tibetans in India (preferably in the Dharamsala area) • Preferably has designed curricula for science, technology, engineering, or mathematics courses to Tibetans (high school level). • Compensation for the participant: $10 one time
	C. Curriculum expert • Must be Tibetans. Can be from a subsequent generation of Tibetans in India. • Any gender • Must be 18 or over • Must understand English • At least 1 year designing curricula for courses taught to Tibetans in India (preferably in the Dharamsala area) • Preferably has designed curricula for science, technology, engineering, or mathematics courses to Tibetans (high school level). • Compensation for the participant: $10 one time
	D. Cultural expert • Must be Tibetans. Can be from a subsequent generation of Tibetans in India. • Any gender • Must be 18 or over • Must understand English • Tibetan Buddhist monk or nun OR an Elder in the community with rich cultural knowledge about any of the following: Tibetan technologies, Tibetan architecture, Tibetan carpentry, artifacts, ways of solving a problem. • Compensation for the participant: $10 one time

Table 3.2 continued

	E. Technical expert • Must be Tibetans. Can be from a subsequent generation of Tibetans in India. • Any gender • Must be 18 or over • Must understand English • Tibetans with at least a B.S. degree OR equivalent in any of the following: science, technology, engineering, or mathematics. Could be a 2-year degree if no person with 4-year degree is found. • Could be working in an engineering- or technology-related job • Compensation for the participant: $10 one time
1[31]	F. Teacher assistant/translator • Must be Tibetans. Can be from a subsequent generation of Tibetans in India. • Any gender • Must be 18 or over • Must understand English • Must have at least high school level knowledge of science and mathematics concepts • Compensation: $10 per class assisted. No more than $20 per week. No more than $160 per entire course.
33[32]	G. Student • For those ages 16 or 17 years, parent or legal guardian must sign a consent form and the student must sign an information sheet. • Must be Tibetan. Can be from a subsequent generation of Tibetans in India. • Any gender • Must understand English • Must agree to attend the group interview and complete a pre-test, post-test, and team project • Required to attend at least 75% of the classes (e.g., 11 out of 14 classes) • Should bring simple classroom materials: notebook, pencils, papers
4[33]	H. Non-Tibetan community member • Non-Tibetans who are knowledgeable of the community and school system on-site • More than 1 year living in the community • Must understand English • Compensation for the participant: $10 one time
52	TOTAL

[31] This participant was also a student of the course.
[32] One of these participants was also the teacher assistant.
[33] The four participants were two Indian teachers, one Ladakhi (Indian) who is a Tibetan Buddhist monk, and a woman from the U.K.

3.4.4.1 Recruiting and interviewing (non-students)

In general, to build trust with any potential participants, I often met with them twice: first to explain the study (and possibly schedule an interview) and second to conduct the interview. For those participants who were far away from TCV Selakui, I met only once (the same day of the interview). In any case (first time meeting or interview), I dedicated an approximate of 15 minutes before each interview to explain the project and the consent form; except for the case of monastics whom I needed to dedicate even more time (30-45 minutes) due to their lack of knowledge about the terminology and the concept of "engineering" in general. In their case, what I ended up doing in subsequent interview was to show them a simple concept map that explained the components of my research project. I also brought with me a copy of the first lesson of the course that explained simply what is engineering with more visual aids than text. These two methods to help monastics understand my project were successful in my opinion because I used more visual aids than English text to help us communicate.

Regarding to recruiting teachers at TCV Selakui, the school administrators suggested some potential participants (e.g., teachers, Tibetan Buddhist monastics, and engineers) based on my recruitment criteria.[34] I had a group meeting to introduce myself and the research project. That was my first meeting with those potential participants. They voluntarily indicated to me if they wanted to be interviewed. All of them indicated to be interviewed individually (not in a focus group).

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[34] See section 3.4.4.

I had three potential participants who declined to be interviewed. All of them identified through snowball sampling. Two of them declined due to travel or work schedule conflicts. One declined without giving me a reason.

3.4.4.2 Recruiting students

The school administrators assisted me in scheduling a proper time and classroom for the students to sign the consent forms and respond to the pre-course questionnaire. I arrived early to arrange the seats and materials and write instructions on the chalkboard, based on the consent forms. I explained each section and individually helped those who needed an instruction clarified. These strategies helped me to communicate more easily with the students.

3.4.5 Transcribing interviews and videos

I transcribed the audio interviews of participants who were concerned about their privacy or participants who used many Buddhist or Tibetan words. An American English speaker transcribed the rest of the remaining interviews, and I reviewed and corrected those transcriptions to ensure their accuracy. One audio interview required translation from Tibetan to English as well as transcription and for this I used the services of a Tibetan translator.

3.4.6 Record keeping

All of the data collected were stored in a locked file cabinet. All of the digital (or digitalized) data was stored in an encrypted hard drive in a laptop, encrypted backup hard drives, and in an online encrypted file storage service. I used TrueCrypt to encrypt the hard drives. Examples of digital data are photos, videos, audio interviews, electronic presentations, and digitalized copies of documents, such as fieldnotes, team progress reports, attendance sheets, and signed consent forms. All the technology and software to accomplish this research were purchased thanks to an Alliance for Graduate Education and the Professoriate (AGEP) grant.

I assigned a unique identifier to each participant. Each student had a unique number, and each interviewee had a category letter plus a number. The category letters were as follows: Tibetan teacher (TT), non-Tibetan community member (NT), Tibetan school administrator (TA), Tibetan cultural expert (TCE), and Tibetan technical expert (TTE). I used a spreadsheet to keep track of demographic information.

3.5 Data collected

This section describes the different sources of data: formal interviews, videos, design progress reports, questionnaires, and fieldnotes.

3.5.1 Formal interviews

I conducted a total of 18 formal interviews. Nine took place on the school site (see Table 3.3) and nine off the school site (see Table 3.4). To conduct these interviews, I followed semi-structured interview guides (see Appendixes K to N). The majority of the interviews took place in the Dehradun district of the state of Uttarakhand, India (where the town of Selakui is located). Few interviews took place in Dharamsala (in the state of Himachal Pradesh, India). To protect the privacy of the interviewees, I do not specify where the interview was conducted. I conducted three significant informal interviews with a teacher, school administrator, and monk. I held numerous weekly informal meetings and interviews throughout my stays in Dharamsala and Selakui, before, during, and after the school intervention. I took notes of these meetings and informal interviews, but I did not audio record them.

Table 3.3 Formal Interviews Conducted at The School

Ethnicity	Category	Specialization	Gender
Tibetan	Teacher	Mathematics	M
Tibetan	Teacher	Mathematics	M
Tibetan	Teacher	Mathematics	F
Tibetan	Teacher	Tibetan culture	M
Tibetan	School administrator	Also teaches science	M
Indian	Non-Tibetan (also a teacher)	Physics	M
Indian	Non-Tibetan (also a teacher)	Physics	M
Tibetan	Teacher and engineer	Mathematics, Electrical Engineer	F

Table 3.4 Formal Interviews Conducted outside of The School

Ethnicity	Category	Specialization	Gender
Tibetan	Tibetan Buddhist monk	n/a	M
Tibetan	Tibetan Buddhist monk	n/a	M
Tibetan	Tibetan Buddhist monk	n/a	M
Tibetan	Tibetan Buddhist nun	n/a	F
Ladakhi [a]	Tibetan Buddhist monk	n/a	M
Unspecified (from the United Kingdom)	Non-Tibetan Community Member	n/a	F
Tibetan	Teacher and engineer	Mathematics, Mechanical Engineer	M
Tibetan	Engineer	Civil Engineer	M
Tibetan	Engineer	Civil Engineer	M

[a] A person from Ladakh, a region in the northern part of India.

3.5.2 Videos

This section provides a record of the videos taken during classes, feedback sessions, testing or follow-up sessions, and project presentations at the school auditorium, with the help of a teacher assistant (see Tables 3.5, 3.6, 3.7, and 3.8).

Table 3.5 Videos Taken of Classes

Date	Class Title
9/3/2012	Lesson 1.1: What is Engineering
9/7/2012	Lesson 1.2: Engineering and Society
9/10/2012	Lesson 2.1: Concepts of Products Design [a]
9/17/2012	Lesson 3.1: What is Sustainability?
9/19/2012	Lesson 3.2: Examples of Sustainable Engineering Designs
9/24/2012	Lesson 4.1: Energy and Energy Alternatives
9/26/2012	Lesson 4.2: How do Alternative Energy Technologies Work?

[a] Lesson 2.2 was skipped because the students were busy at that time with more important after-school activities (preparing the school for the Dalai Lama's visit on September 15, 2012).

Table 3.6 Videos of Feedback Sessions

Date	Team(s) who received feedback
9/10/2012	3,5,7
9/19/2012	5,7,8
9/21/2012	1,2,3,4,6
9/24/2012	1,2,6
9/26/2012	8,6
9/30/2012	1,3,4,5,7
10/3/2012	1,6,8
10/5/2012	3,2,7
10/8/2012	All teams (electronic presentation feedback)

Table 3.7 Videos of a “Testing” Phase or “Follow Up” Sessions[a]

Type	Date	Team
“Testing”	10/9/2012	2
“Testing”	10/11/2012	3,4
“Follow up”	10/12/2012	5,7,8

[a]In a “testing” phase a student team tested its design to identify faulty conditions. In a “follow up” session, the team reported the final successes or failures of its design (in the case of those teams who could not test their projects in front of me).

Table 3.8 Videos of the Implementation Phase

Date	Team
10/9/2012	2

The final project presentations were held in the school auditorium on October 10, 2012. The teacher assistant recorded all eight team presentations and project demonstrations on stage.

3.5.3 Teams' progress reports and questionnaires

Each team submitted three progress reports and an electronic presentation about its project. I used these artifacts to guide the teams throughout their design processes, help them reflect on their design decisions, and research my two questions. I provided Report Guidelines (see Appendixes A to D), which they used to report their progress. I also provided guidelines for the final project presentations (see Appendix D).

I asked the students to respond to a pre- and post-course questionnaire. The objective of the pre-course questionnaire was to gain an understanding of their knowledge of engineering, engineers, sustainable engineering, sustainability, and their future career goals, among other things (see Appendixes P and Q). Other questions were relevant to my second research question, such as "What does it mean to be a Tibetan?" and "What makes a person a Tibetan?"

The post-course questionnaire focused more on gathering feedback about the course and design project (see Appendix Q). The first section posed similar questions about engineering, engineers, and sustainability. The next section sought to understand whether or not the course motivated them to consider studying engineering. The remaining sections sought to understand whether the teaching, design project, feedback sessions, and course content met their expectations and to solicit critiques and recommendations (see Chapter 4, section 4.7).

3.5.4 Fieldnotes

I frequently wrote fieldnotes, reflections, and plans (collectively, "fieldnotes") in notebooks for later digitization. By the end of each week, I integrated all of that week's fieldnotes in one document to report to my adviser or for record keeping. Table 3.9 shows how many fieldnotes were written every month (weekly summaries are not included in the totals).

Table 3.9 Fieldnotes Written per Month (Not Including Weekly Summaries)

Number of fieldnotes	Month
3	March 2012
10	April 2012
5	May 2012
20	June 2012
20	July 2012
18	August 2012
19	September 2012
17	October 2012
4	November 2012
5	December 2012

After I gathered the data, I transcribed the audio interviews (with the help of transcribers) and typed the students' questionnaires and each team's progress reports. This phase lasted from December 2012 to approximately August 2013.

3.6 Grounded theory data analysis methods

To analyze the data, I used grounded theory methods (Birks & Mills, 2011; Strauss & Corbin, 1998). A "theory" in this analysis method is "an explanatory scheme comprising a set of concepts related to each other through logical patterns of connectivity"

(Birks & Mills, 2011, pp. 112-113). A good grounded theory analysis is driven by the research questions, goals, and units of analysis (Birks & Mills, 2011).

Strauss and Corbin (1998) identified three phases of coding analysis: open, axial, and selective. These analytical phases are iterative and not linear (Birks & Mills, 2011). *Open coding* is a reflexive activity and is often accomplished by analyzing documents line-by-line or by sections (Strauss & Corbin, 1998). Eventually, the initial coding will become redundant when the researcher gains more familiarity with the data concepts (Birks & Mills, 2011). *Axial coding* refers to the generation of categories based on low-level conceptual codes (identified in the initial coding phase). A point of theoretical saturation arrives when no new codes are identified (Strauss & Corbin, 1998). Finally, *selective coding* is accomplished through the storyline technique (Strauss & Corbin, 1998). A storyline is a narrative that the researcher uses to describe the central phenomenon of the study (Birks & Mills, 2011). A storyline helps to produce a theory and to provide ways through which the theory can be communicated (Birks & Mills, 2011).

After I completed the transcribing phase, I imported all of the data (fieldnotes, transcripts, reports, and questionnaires) to an NVivo project. NVivo is a qualitative research software package used for data analysis. I read the data sources to assign units of data to codes. I defined four types of codes: in vivo, process, descriptive, and holistic. *In vivo* coding uses the literal quotes of a participant to name the code (Saldaña, 2009). *Process* coding (Saldaña, 2009) uses gerund verb tenses to describe participants' or my own actions. *Descriptive* coding assigns a descriptive word to the associated data

(Saldaña, 2009). *Holistic* coding (Saldaña, 2009) assigns a code to a large paragraph, rather than a sentence. This became my open coding analysis phase.

In the axial coding phase, loose codes were grouped together based on their similar name descriptions. I examined the data sources connected to each code and identified which were redundant or which should be assigned to other codes. For example, those with (a) equivalent code titles and same data sources and (b) different code titles but same data sources. In addition, I identified sub-codes from the major codes. For example, some sub-codes explained steps, processes, or phases to achieve an action (e.g., design process of students). These sub-codes also organized data that described the previous steps taken to achieve an action and their consequences (e.g., “before teaching,” “during teaching,” and “after teaching”).

I discarded codes that did not contribute to answering the research questions. I assigned codes to categories. In this step, I created concept maps that revealed whether certain categories overlapped with others. The map also helped me to reorganize the codes within and between the categories. In the end, I moved the data and titles of each category to a word processor document to define chapters and sections.

In the selective coding phase, I wrote interpretations of the data associated with themes (or “chapter sections”). These interpretations formed narratives, and thus storylines (Strauss & Corbin, 1998), and were triangulated with previous scholarly work and participants’ responses (e.g., teachers’ interviews triangulated some of my interpretations of the students’ responses). After I wrote the storylines, I identified and discarded the chapters and sections that did not contribute to answering the research questions. In addition, I reordered the sections within and between the chapters.

To help communicate my data analysis to readers, I used data displays such as concept maps and matrixes (Miles & Huberman, 1994). Data displays help with understanding of concepts, data flow, connection, and location of the phenomena being analyzed (Miles & Huberman, 1994). Matrixes are a good choice to present findings across cases (Miles & Huberman, 1994). Concept maps are used to show how themes connect to each other (Miles & Huberman, 1994). In Chapter 4, I use concepts maps to graphically summarize the findings of the students' course feedback and my processes to develop and implement the course. In Chapter 5, I use matrixes to present the findings of how the students and engineers thought that Buddhist-*Mahāyāna* beliefs and practices supported their engineering design and teamwork. In Chapter 6, I use matrixes to display the findings of the different sources of influence in each team's design project and teamwork. In both cases (Chapters 5 and 6) matrixes were a good choice to present the findings in order to make comparisons between engineers and student teams, and within each group's case (e.g., between student teams).

A conceptual framework (Miles & Huberman, 1994) helped me to make initial theoretical statements. For research question 1 (see section 3.1), I was informed by references about culturally responsive education, intercultural education, and multicultural education. For research question 2 (see section 3.1), I was informed by Tibetan studies, Buddhist studies, and postcolonial studies (see Chapter 2 for the literature review).

Because this study used ethnographic research methods, my interpretations must be situated within a framework. My thought process and interpretations can be categorized in postcolonial theory because of my sociocultural background described in section 3.3 and the way that I interpreted the intercultural “clash” between my students and me. In the next subsection, I introduce postcolonial theory and the scholarly work on which I built my interpretations of this ethnographic research study.

3.6.1 Data analysis theoretical framework

This section provides a summary of postcolonial theory, upon which my data analysis and ethnographic research interpretations are based. Postcolonial theory is broad, but my critical perspective mostly aligned with four scholars’ work: Donald S. López (1998), Dibesh Anand (2007), Edward W. Said (1994), and James G. Carrier (1992). The first two scholars have published in both Tibetan studies and postcolonial studies. The last two are mostly known for their work on the notions of Orientalism and Occidentalism, respectively.

3.6.1.1 Postcolonial theory

Hansen (2002) provided a short summary of postcolonial (or subaltern) studies:

> Subaltern studies began in India as an effort to rewrite history ‘from below’ by historians on the left who were dissatisfied with prevailing Marxist and nationalist interpretations of Indian history. They adapted Antonio Gramsci’s concept of the ‘subaltern’ to signify the subordinate position of peasants and other people subject to various forms of domination. Early work in subaltern studies was concerned

> with peasant insurrection, revolution, and ‘resistance’ in many forms. Subaltern studies scholars soon shifted attention from recovering the agency and self-consciousness of peasants and workers to study of the representations of subalterns by the colonial state, nationalist movements and elite discourses. Michel Foucault’s perspective on power and Jacques Derrida’s critique of discourse were both influential as subaltern studies evolved into a broad postcolonial critique of knowledge and power. From these perspectives, ‘subalternity’ was not an autonomous position outside dominant discourses, but rather an effect of the dominant discourses of colonialism, nationalism and modernity. (p. 8)

The field of Tibetan studies has predominantly been written about from an Orientalist perspective (Hansen, 2002); however, authors such as López (1998) and Anand (2007) have provided a postcolonial perspective on the history of Tibet and the Westerners’ interactions with Tibet, Tibetans, and Tibetan Buddhism. For example, Anand (2000, 2003, 2007) argued that the construction of a Tibetan identity (inside and outside of Tibet) is in constant negotiation and renegotiation with (a) each Tibetan’s individual experiences coupled with Tibetan nationalism, (b) transnationalism, (c) the image of the homeland Tibet and its re-imagining in exile, (d) the Dalai Lama’s role on the reconstruction of Tibetan Buddhism and Tibetan culture in the West, (e) the displacement discourses of Tibetans in exile, and (f) the “exotica Tibet” (Anand, 2007) phenomena that emerge from the interaction between Tibetans’ and Westerners’ imaginations and desires about Tibet.

Hansen (2002) argued that Tibetan studies have remained under an Orientalist perspective because of the "constructed official nationalist narratives" about Tibet (p. 10). Because the subaltern critique is in opposition to the dominant discourses of the state and elite discourses, it is understandable why researchers have not adopted this perspective (Hansen, 2002), let alone Western scholars who practice Tibetan Buddhism (such as me). These types of critiques can destabilize the "mysticism" of Tibet and Tibetans, the dominant narratives that fuel the interactions between Western converts of Tibetan Buddhism and Tibetans in exile.

During the analysis phase, I realized that my intervention as a teacher at TCV Selakui revealed a clash between my experiences and interpretations of Tibetan Buddhism and Tibetan culture and those of my students. In other words, it was a clash of imagined cultures: On the one hand, my students' Occidentalism, that is, the imagined West and Westerners; on the other hand, my Orientalism, that is, my expectations of Tibetan culture, Tibetans, and Tibetan Buddhism, which were shaped by the narratives of Tibetan cultural authenticity by Tibetans in exile, Western media, and Western Tibetan Buddhist centers.

In summary, my intervention as a Western teacher trying to be culturally responsive revealed a clash between my Orientalism (Said, 1994), the students' Occidentalism (Carrier, 1992, 1995), and my students' interpretations and experiences of their own culture and Buddhism. Because I have interpreted it as such, I have chosen to focus my postcolonial framework on the work of Edward Said (1994) and James Carrier (1992), who talked about the effect of Orientalism and Occidentalism in intercultural settings.

Said's (1994) notion of Orientalism is defined as "a school of interpretation whose material happens to be the Orient, its civilizations, peoples, and localities" (p. 203). It is also an "academic tradition" (p. 203) whose essence is "the ineradicable distinction between Western superiority and Oriental inferiority" (p. 42). It is constructing the identity of the West by opposition: by constructing the East and pointing out how the West is different or superior to that opposite identity (Carrier, 1992; Said, 1994). In contrast, but following Said's (1994) theory, Carrier (1992) wrote about Occidentalism, or the essentialization of the West by Western researchers and non-Western people. Examples of research on Occidentalism include the study of representations of Western culture and Westerners in Japanese advertisements (Creighton, 1995) and the study of the representations of Western technocratic reasoning in South Asia (Spencer, 1995).

Chapters 4, 5, and 6 present my data analysis using a postcolonial perspective in a quest to understand (a) how Tibetan culture and Buddhism influenced my students' design projects and teamwork and (b) the processes by which I developed and implemented the course.

3.7 Summary of the research and data analysis framework

To summarize the components of my research and data analysis at a high level ("bird-eye view"), the main components and most important subcomponents are as follows:

- Research design
  - Case study
  - Ethnographic research methods
- Research methodology
  - Decolonizing research methodologies
- Research instruments
  - Teacher's (self) journal
  - Teacher's (self) fieldnotes and observations
  - Semi-structured interview guides
  - Design progress report guidelines
  - Pre- and post- course questionnaires
- Data analysis methods
  - Grounded theory methods
  - Postcolonial theory

CHAPTER 4. HOW DID I DEVELOP AND IMPLEMENT A CULTURALLY RESPONSIVE INTRODUCTORY ENGINEERING COURSE?

4.1 Introduction

This chapter focuses on answering the first research question: What are the processes to develop and implement a culturally responsive introductory engineering course? To answer this question, I analyzed my fieldnotes, interviewees' transcripts, and students' feedback reports.

The chapter is organized as follows. The first four sections discuss the design of the content, pedagogy, "assessment," and progress report guidelines that follow the structure of Drs. Streveler's and Smith's course, "Pedagogy, Content, and Assessment," (ENE 506) taught at the School of Engineering Education, Purdue University (Purdue University, 2014). The Section 4.5 explains the process of preparing to teach the 6-week course, which took more time than teaching the course itself. This phenomenon aligns with the findings of other scholars who have reported that culturally responsive approaches of teaching take more time and effort to prepare than do other approaches (Castagno & Brayboy, 2008).

Preparing to teach abroad requires dedication, all the more so when you are a foreigner, are not versed in the language of the people, and do not belong to the cultural group of the students. Scholars have noted the importance of language and cultural education before teaching abroad (Herman & Bailey, 1991). International development organizations such as Peace Corps provide cultural immersion classes to prepare volunteers before going abroad to teach (Clark, 1998; Downey & Beddoes, 2010). Even global engineering programs prepare (or encourage) engineering students with cultural immersion classes before they travel abroad (Downey, Lucena, & Moskal, 2006). In addition, even in the United States, much effort is placed in training pre-service teachers with culturally responsive pedagogy (Amatea, Cholewa, & Mixon, 2012; Ambe, 2006; Breault, 1995; Morrison et al., 2008). Therefore, I assumed that it was important for me to take time to learn about my students and school community. I stayed in TCV Selakui for 3 months before teaching not only to interview teachers, but also to better learn how to be a culturally responsive teacher and to adapt my teaching strategies to the school context. Although perfection is impossible, being responsible to learn from and about the local school community is within one's reach.

The evolution of the course that I taught at TCV Selakui did not begin in fieldwork, but rather early in my first year of the doctoral program at the School of Engineering Education, Purdue University. The course combined the knowledge and experience acquired in these courses: "Pedagogy, Content, and Assessment" (ENE 506); Dr. Enerson's course "Qualitative Research Methods in Education" (EDCI 615); Dr. Nies' course "Sustainable Design" (CE 597); and Dr. Braun's course Sustainable Energy Options and Assessment (ME 597). It also reflected the experiences acquired in (a) a short presentation about "The Engineering of the *Ger*" (a traditional Mongolian nomadic house) that I presented at the Mongolian children's summer camp held at the Tibetan Mongolian Cultural Center in the summer of 2011, (b) a workshop that I conducted at the *Sakyadhita* conference for Buddhist women in the summer of 2011, (c) a book chapter I wrote for an Engineering and Social Justice book edited by Juan C. Lucena (2013), and (d) two "Engineering & Society" references by Baillie and Catalano (2009) and Lucena et al. (2010).

From the Content, Pedagogy, and Assessment course, I used documentation about structures constructed by Yupik Alaskans to make associations between the engineering design cycle and the elders' descriptions on how the structures were constructed. I was also inspired by literature on the intersection of culturally responsive education, ethnomathematics, and ethnosciences. From the Qualitative Research Methods course, I developed a short proposal for a pilot study in a Mongolian children's summer camp. The proposal included a copy of an educational module that I used to document the ways to construct (and live in) a Mongolian *ger* to provide a short introduction about engineering design. From the Sustainable Design course, I incorporated into weeks 3 and 4 of my lesson plan information about sustainability and energy. Finally, from the Sustainable Energy Options and Assessment course, I incorporated into week 4 of my lesson plan basic information about how wind energy, tidal energy, and other alternative energy technologies work.

In the 2011 *Sakyadhita* conference of Buddhist women, I taught a workshop on how to refer to Buddhist concepts to help Buddhist students in developing regions (who do not have knowledge about engineering) understand the basics of engineering design and the work of engineers. I took observations, wrote my reflections, and I gathered feedback from the workshop participants. This experience, along with the Mongolian children's summer camp fieldwork, assisted in the preparations for my formal fieldwork in Tibetan communities of northern India. While writing the chapter for Lucena's book project (2011-2013), I explored how the *Mahāyāna-Bodhisattva* Buddhist path, especially the practice or "cultivation" of the six virtues (*pāramitās*), can be relevant in the work of engineers or engineering educators. The engineering and social justice book series (Baillie & Catalano, 2009; Lucena et al., 2010) helped me to (a) design a class period (one session) dedicated to the connection between technology and culture, (b) design a reflective exercise in which the Tibetan students read a college-level global engineering project description and provided their critique and reflections about the design process, and (c) add reflective questions about culture, technology, and society in some of the class presentations.

4.2 Content and "assessment"

I began to draft the course content while at Purdue University in 2011. Between April and May 2012, I worked on the draft content while staying in Dharamsala. Then, after moving to Selakui in June 2012, I edited the content, structure, and teaching strategies based on the teachers' recommendations, what I learned about the students, and what I observed around the school.

Through interviews, the teachers provided insights on the students' educational levels. They assured me that the majority of the students were familiar with the topics of the course, except for some of the energy topics of class 4.1. Several teachers suggested that I directly explain to the students (a) how the class content would be helpful to them and (b) how the design project relates to the real work of engineers; therefore, I included an introduction and summary slide in each electronic presentation to directly answer those questions. I also changed the progress report guidelines and feedback session methods to reinforce the connection between what the students were doing and engineers' work.

The principal expressed concern about the students' commitment levels, because the course would be taught after school and would not be part of the standardized curriculum. We agreed that I would provide some kind of grading sheet, besides the final certificate of completion, and that those students who participated in my course would not be required to complete the school's Science Day (science fair) project. Our intention was to ensure that the students would not end up doing both projects during the same time frame. Therefore, I believe that students received extrinsic motivation to participate in my course in that they did not need to complete the Science Day project if they participated in my course. This decision was not made with the rest of the science teachers, which according to my observations became a sensitive issue of power imbalance. Reed (2011) also experienced being in a position of privilege when teaching abroad:

> Members of a dominant or dominating group are rarely aware of their privilege because it is invisible to them. This invisibility is also a form of power (Delpit, 2006), a kind of political or existential privilege whether or not it is it sought or even noticed. (p. 365)

Foreign teachers/researchers must be aware of the time constraints on school personnel and adapt to their schedules and availability—even extend their stay, if possible. For example, I observed that the teachers had dual and many responsibilities as both teachers and staff members; therefore, I tried to approach them only when they were not helping the students (e.g., break or lunch time). Other scholars have noted that foreign teachers must equip themselves with nontechnical skills that will help them to succeed in their intervention abroad:

> We found that the characteristics of patience, humility, flexibility, understanding, and sensitivity seem to best capture some of the attitudes and behaviors that enhance foreign teaching. (Herman & Bailey, 1991, p. 117)

Although potentially creating a power imbalance, the decision was made by the principal and me that I would provide an "assessment" of the teams' work. This "assessment" was meant to notify teachers, principal, and director about which students worked on the project and the quality of their work from my perspective (for reporting purposes only). In this way, those students who worked on my project did not need to work on a Science Day project. To this end, I decided to modify a rubric sent to me by a colleague from the EPICS (Engineering Projects in Community Service) program at Purdue University (see modified version in Appendix H). I chose this rubric over others because my pre-college engineering design course mirrored a community service project: The students designed a possible solution to a "real" problem identified by a group of individuals in the school community. Because EPICS focuses on providing students with real engineering design experience through community service projects, I assumed there would be a relationship between the two. Furthermore, the rubric was straightforward to follow.

With the rubric, I evaluated each team's performance and not each individual's performance (see Figure 4.1). I retained the grading categories (low passing, adequate, good, and excellent) from the original rubric, but I changed the A to F grading score to points (0 to 12). The first column at the left shows the five broad criteria, which are based on the most important project features and what I wanted the students to learn. Each criterion has outcomes, and each outcome has points. The sum of the outcome points in a criterion is 12, corresponding to the highest grade assigned to each criterion. So, an A+ in the original rubric became a 12 in my modified version.[35]

	Excellent			Good			Adequate			Low passing			
	(12)	(11)	(10)	(9)	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)	(0)
Accomplishments and Overall Quality: 1) Submitted the three project reports (3) 2) Presented their project (3) 3) Followed project instructions and answered guidelines questions (3) 4) Clear understanding of the design problem and constraints (requirements) (3)													
Reflective/Critical Thinking: 1) Team was able to reflect on how their values, beliefs, and identity as a Tibetan influenced their project and team work (5) 2) Project reflected consideration of social, ethical, environmental, and economic aspects (4) 3) Decisions were taken based on appropriate investigation (e.g., online references, books, interview with people, etc) (3)													
Teamwork/Leadership: 1) Team worked together to accomplish project and individual goals (4) 2) Appropriate division of tasks (4) 3) Dedication to meeting stated deadlines (4)													
Engineering: 1) Team was able to explain in terms of engineering concepts (applied physics, scientific, or mathematics knowledge) how their design works (12)													
Sustainability: 1) Team was able to explain why their design can be considered sustainable (12)													

Comments:

Final grade: /60

Figure 4.1 My rubric modelled after an EPICS rubric

[35] I designated 12 levels of quality, but it seems to me that what I ended up doing was to omit the center column of each grading category (e.g., "excellent," "good," "adequate," and "low passing"). In that way, I ended up with 6 levels of quality rather than 12.

The criteria were (a) Accomplishments and Overall quality, (b) Reflective/Critical Thinking, (c) Teamwork/Leadership, (d) Engineering, and (e) Sustainability. The first criterion evaluated whether or not the team fulfilled the requirements (e.g., submitted three reports and submitted the electronic presentation), followed the guideline questions, presented the project in the auditorium, and demonstrated an overall understanding of the design problem and requirements). The second criterion evaluated whether or not the team members reflected on how their values and culture influenced their design and teamwork; considered environmental, ethical, and economic factors in their projects; and made their decisions based on evidence (e.g., interviews of people and references). The third criterion evaluated time management, project management, team building, and appropriate division of tasks. The fourth criterion was added to comply with the administration's requirement that the project clearly connected engineering to science. Basically, I assessed whether or not the students explained their projects using engineering or science concepts. The fifth criterion evaluated whether or not they justified their design as sustainable. Finally, a comments box allowed me to communicate other details about the team to the teachers.

Each team was assessed using this rubric, which had a "symbolic" status in the teachers' records because the grading system of secondary school (10+1 and 10+2[36]) follows the Central Board of Secondary Education (CBSE) standardized curriculum and assessment, a board based in New Delhi, India, that defines the educational standards to those affiliated schools. There is no flexibility for teachers to design their own rubrics

[36] The equivalent of 11th and 12th grades in the United States.

because both the content and assessment methods are standardized. Section 4.5.1.1 provides more details about these standards.

4.3 Challenges of pedagogy

As explained in Chapter 2 (section 2.5.1) the pedagogy was influenced by culturally responsive teaching. This section describes the challenges that I faced while teaching the course, which contributes to answering the first research question.

At the end of the first week of class, Team 2 (the team of 10+2 students[37]) told me that they were having difficulty identifying a problem at the school for their design project. After our conversation, I realized the need to shorten the lectures so that I could focus more on each team's design progress because if this team of 12th graders was having difficulty, then the teams of 11th graders were likely having even more difficulty undertaking the project without assistance. I dedicated Mondays and Wednesdays to lectures and Fridays to meeting with each team; I increased the number of meetings in the last week. I reduced class time from 60 to 40 minutes on those days when I met with a team. I was able to schedule two to three team feedback sessions per day and was careful to limit each feedback session to 5 to 15 minutes.

This region of northern India has frequent power outages. I learned early on that I had placed too much emphasis on teaching via electronic presentations. We lost power on the first day of class, and I had not planned an alternative way to present my lecture.

[37] Equivalent to 12th grade in the United States.

Fortunately, I had provided handouts of my presentation to all of the students so that they could revise them and later refer to them, which became a standard practice.

I arrived 15 to 20 minutes before the start of each class to arrange the chairs and set up my electronic devices. At first, the teacher assistant helped me to distribute papers to students, but I eventually decided to put all papers on a counter so that each student would pick them up individually.

In a class about sustainability, I drew a concept map about the different sources of energy on the board because I thought it was important for the topic and the handout was blurry. From the student's facial expressions, I concluded that the concept map was difficult for them to understand, possibly because they were not accustomed to structuring ideas in that form. At that moment, I was not confident that I would be able to successfully express my ideas through the concept map, which probably compounded the problem. Roth and Roychoudhury (1992) wrote that the use of concept maps in high school science education has the advantage of helping students to learn the language pattern of science that is needed to construct scientific knowledge. As a disadvantage, however, students end up using short sentences or single words to explain a phenomenon, rather than complete sentences or more complex propositions (Roth & Roychoudhury, 1992). Therefore, before using concept maps in English, teachers should consider the English language level of students.

One of my biggest challenges involved engaging students in the classroom—encouraging them to respond to my reflective questions. It was not until the last lecture that they became more engaged in class and even answering my questions. For example, in the class about Engineering and Society (in the first week of class), I presented photos about the manual processes to make *tingmos* (steamed bread). I asked, “If a mechanical engineer is going to design a machine to produce *tingmos*, how important is to understand the steps to make them?,” “Can a *tingmos*-producing machine designed by an engineer be beneficial in all contexts?,” and “If we put the machine in home #6, could it limit (or facilitate) the transfer of knowledge on how to make *tingmos* to the next generations [of Tibetans]?” No one raised his or her hand to answer these questions during the first lecture.

My goal in asking those questions was to help them reflect on the connection between technology and society. I believe that the students did not respond because of a combination of factors. First, I presented this topic in my second class, when I had not yet earned their trust. Second, even though they attend a Tibetan school, in upper class (high school) they are taught an Indian standardized curriculum developed by the CBSE, which means that their science education is impacted by a positivist paradigm. This paradigm says that “science research methods are objective” (Fleury, 1997, p. 169). Because of this perspective on science, and because their concept of engineering is “physics and mathematics,” it is understandable why some students experienced difficulty reflecting on the impact of society on engineering (and vice versa). In addition, their expectations of me as a teacher from the West may have been influenced by their perception of what Westerners believe, think, and expect. In other words, their Occidentalism (Carrier, 1992) regulated their expectations and interactions with me.

The students showed more attention when I presented videos that explicitly depicted the design jobs of engineers. For example, most students seemed very interested (i.e., looking fixedly at the screen with amazement) when I showed an AutoCad video

(Autodesk Sustainability Workshop, 2012) that presented an Ashby diagram that helps engineers select proper sustainable materials to design a product (in this case, a car). They also showed great interest when the videos related to poverty alleviation or engineering-related projects that directly help poor communities. After I showed a video about light bulbs made of plastic bottles and chlorine as an alternative to regular bulbs (loQal.ph & Yahoo! Southeast Asia, 2011), a Tibetan girl asked me after class to show more videos like that one. In addition, two students requested copies of the video to use in other assignments.[38] Even though the video was filmed in the Philippines, the students were interested in the concept of innovations being used to help to alleviate poverty. As a result, I recommend that teachers use videos of not only engineers in industry settings, but also of engineers working to alleviate poverty. This approach is culturally responsive, especially to those who place great value on altruism, no matter their religion.

During class 4.2, I showed a video about how a wave power station works. I was not certain that they would be interested because they do not live near the ocean, but to my surprise the majority looked amazed (e.g., looking at the screen with eyes wide open). Similarly, the students were very attentive during class 3.1 when I showed a video of e-waste workers in New Delhi, making me more aware of their reality; even though they are ethnic Tibetans, they live in northern India (the majority as refugees) and therefore social problems in India are relevant to them.

These observations of my students' interests in engineering-related videos (including how engineering can help to alleviate poverty) lead me to believe that a

[38] That video was recommended to me by Lindsey A. Nelson, a doctoral candidate in my adviser's research group.

"culturally responsive" course can expand its focus on cultural elements (e.g., architecture and arts) and the community context to incorporate multicultural information, as argued by Gay (2000). Furthermore, videos should not be limited to only those showing engineers at work in industry. If we wish to introduce a social justice and sustainability component, and if we wish to help students understand that engineering is more than physics and mathematics, then we should show videos in which engineers are supporting projects aimed at alleviating poverty and in which sustainability is defined as more than alternative energy technologies. To be culturally responsive, the content does not need to be framed in terms of geographical location (in this case, northern India, Tibet, or the school); it can also be framed in terms of important societal values such as altruism and compassion.[39]

4.3.1 Feedback sessions

This section discusses how I managed feedback sessions with each team, which was another form of teaching. As discussed in section 4.3, I did not originally plan to incorporate feedback sessions into the course, but I realized that the students needed my encouragement and support to be successful in their projects; even more so because it was their first time experiencing a design project like the one I proposed.

As part of the course, the students had to design a solution for a problem at the school. This was a hands-on design project, similar to what students experience in EPICS. To support their progress, I met with the teams individually each week for 5 to 15

[39] "Compassion" in a Buddhist context is the wish or actions to help alleviate dissatisfactions and sufferings.

minutes. I provided feedback, written down on a photocopy of their original project progress report, which the teams kept for future reference. Scholars have argued that help from "experts" can guide students through their design activities (Cunningham, Knight, Carlsen, & Kelly, 2007; Edward & Middleton, 2002). In this case, I shared my expertise in the form of feedback sessions and written commentaries in the margins of their reports.

I supported my communication with diagrams and hand gestures. In fact, other scholars have noted that non-English speakers in mathematics and science learning contexts often make use of hand gestures to communicate (Crowder, 1996; Domínguez, 2005; Singer, Radinsky, & Goldman, 2008). I also made use of positive phrases that acknowledged their progress (confirmation words), for example, "You are doing good work" or "You are going on a good path." Hsu (2012), who studied the influence of teachers' vocal qualities and confirmation behaviors, found that the use of confirmation behaviors by nonnative-speaking teachers enhanced students' receptivity to his or her teaching.

For every step of a team's design process, I made connections between what they were doing and the work of an engineer (or project designer). Other scholars have stressed the importance of explicitly connecting the students' design activities with the "real" work of professional engineers. Quayle (2010), for example, proposed a framework for college-level engineering education that integrates teaching engineering science, engineering design, and engineering commercialization. Alekseevich, Alexandrovich, Ivanovich, and Stanislavovich (2012) implemented a program to train molecular physics students at a level equivalent to the professional activities of a practitioner, based on Vygotsky's contributions in the field of educational psychology.

I had to ensure that each team had the resources to do the project. Some teams did not spend money because the requirements were to reuse locally available materials, but there were exceptions. One team paid 30 Rupees (approximately 60 U.S. cents[40]) to buy a tape. I encouraged those who owned or had access to digital cameras to take pictures of their work. In addition, I had to be concerned about the students' security. For example, Team 7 had several ideas for a project, one of which was to design a snake trap. After learning that snakes in that region are poisonous, I asked the team to choose an alternative project.

For the "sustainable design" component, I required the students to reuse materials and use biodegradable resources. They satisfied this requirement by (a) reusing plastic bottles, (b) reusing iron rods, (c) reusing small wheels, (d) using alternative sources of energy (e.g., mainly gravitational and manual), and (e) borrowing materials from staff members (evidence that the community was also engaged in the projects). The sources from which I drew my definition of "sustainable design" was a combination of (a) a sustainability framework (Rao, Pawley, Hoffmann, Ohland, & Cardella, 2010), (b) basic introduction to energy and energy alternative technologies, (c) the work of Waste for Life (2013), and (d) relevant videos found on the Internet (see the list in Appendix Z).

I wanted to offer a variety of topics to introduce students to the different engineering disciplines, yet at the same time I wanted to provide relevant information on how engineers can shift their thinking to consider environmental factors to prevent pollution and waste. This was my attempt to create a curriculum that is not only culturally

[40] When I stayed in India in 2012, 60 Rupees was approximately the equivalent of 1 kg. of dried lentils or almost the price of a quart of juice.

relevant, but also socially relevant to where they live because India has a critical waste management problem (Sharholy, Ahmad, Mahmood, & Trivedi, 2008), which I also observed throughout my stay in India, and there are global efforts to transition to renewable energy resources (United Nations Development Programme, 2013).

Scholars argue that it is important to help students reflect on the assumptions of engineering and design (Claris & Riley, 2012; Pritchard & Baillie, 2006). To aid this process, while reviewing the teams' reports, I wrote clarifying questions in bubbles on the report pages (see section 6.5.2 for examples). For example, Team 7 used words like "appropriate size" and "easily" when describing the rat cage. I asked them to clarify what those terms meant to them within the context of their design and the problem to be addressed. As another example, Team 5 designed a bell ringer, but they overlooked the person who rings the bell, who was an Indian female worker. On one of their reports, I asked whether they considered her height and physical strength, for example, but it was unclear to me whether or not they did so.

Almost all of my students identified "time management" as a big issue in their design projects. When they talked about "time management," they referred to "lack of time" to do the project, which is legitimate since the design project was an extra-curricular activity that competed with their other academic and student community service obligations. In other hand, this challenge to manage time could have a developmental explanation (for a cross-cultural study of prioritization of time, see Fuligni & Stevenson, 1995). Another explanation could be cultural perception. Cultural perceptions of time prioritization by teams have been explored by other scholars (Macduff, 2006; Saunders, Slyke, & Vogel, 2004; White, Valk, & Dialmy, 2011). My goal was to provide the students with the experience of design as close as possible to a first-year college engineering project, but this implied exposing students to the Western cultural notion of time, which focuses on management, productivity, linearity, and structure (Lee & Liebenau, 1999).

The rigidity of our Western-based engineering partially results from what Cavallaro (2001) argued is the Western notion of a life structured around time and a perception of time as linear and not circular. Therefore, I question to what extent their perceived difficulty to manage their time was a combination of their cultural perception of time and their developmental level. Western teachers inevitably bring their Western culture to their teaching (Shi, 2009). Western pre-service teachers (who want to be both culturally responsive and socially just) should be mindful that even “trivial” notions such as “time” may not be perceived and defined equally in different cultures where one will teach. In addition, students may not be developmentally capable of prioritizing time, particularly within teams. Therefore, teachers must implement strategies to help students to develop these skills as part of their design project.

From their submissions, I noticed that many students forgot to cite their sources of information, even though it was one of the report requirements. As Hayes and Introna (2005) summarized, “[S]ome overseas students are said to plagiarize, both intentionally and unintentionally, due to their lack of experience in essay writing, as many Eastern countries still rely exclusively on examinations (Ashworth et al., 1997; Carroll & Appleton, 2001)” (p. 215). It is possible that they did not understand from my explanation why it is important to give credit for others’ ideas, even if they are found on the Internet. Only the 10+2 students were able to clearly cite their information sources:

they referenced the Web site where they found ideas for designing their own bamboo cart. Several teams just wrote “Google” as their source in the “References” slide of their final project presentations. It could be that they experienced technical difficulties and time constraints when using the Internet, because power outages are frequent in the region. Multiple factors—their culture, the ways of teaching and learning in India, and technical difficulties—could have impacted their referencing skills.

The design progress report guidelines helped me to customize my feedback to each team.[41] These were similar to “questionnaires” or “take-home assignments” (see Appendixes A to C). The next section provides detail about how I developed these reports.

4.4 Design of progress report guidelines to guide the students throughout their design projects

When I learned that the team of class 10+2 students needed my support in their design process, I decided to place an extra effort in the design feedback sessions. For example, I explained them how what they were doing was like the work of an engineer, and I encouraged them with positive reinforcement phrases. After the teams submitted their first progress reports, I redesigned the next one based on their progress and my failures; therefore, the design of these instruments was an iterative process. I was able to customize these guidelines in such a way because my course was not bound by a

[41] I also provided a summary of the structure of these reports in section 3.3.1.

standardized curriculum. Each subsequent report was designed based on what I learned from the previous one.[42]

The report guidelines sections were (a) an introduction that explained how the team's work was associated with the work of engineers, (b) sections that separated the question topics (e.g., questions about culture and Buddhism were separated from those about engineering), and (c) a hypothetical example of what I would expect from their responses. As mentioned previously, a local school teacher suggested that I make clearer the connections between the class content, design project, and the work of engineers. Therefore, based on these recommendations and informal conversations, I realized the need to be more direct in my explanations of the value of the design project and course content.

Even though the hypothetical examples that I added in the reports were developed through my Western point of view, my goal was to provide guidance around what I was asking the students to do. (See Appendixes A to C for examples of the hypothetical examples that I used to help students visualize what I was asking for.)

In the third iteration of the report guidelines, I added a section marked by a border in which I added reflective questions about Tibetan culture and Buddhism in relationship to their design project because I wanted to keep better track of the teams' responses. I copied the same questions below, as they were written:[43]

1. How do you think that Tibetan dialectics [debate][44] is influencing your (1) team work and (2) design process?

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[42] See Appendix AA for a list of changes from one report to the next.
[43] You can see the original text on the second page of appendix C.
[44] I will discuss the importance of this way of learning in section 5.4.1.

2. How do you think that [the six virtues] ([each virtue separately])[45] is influencing your (1) team work and (2) design process?
3. How do you think that the ideas of emptiness, dependent origination, and/or interdependence are influencing your (1) team work and (2) design process?
4. How do you think that your Tibetan beliefs are influencing (1) team work and (2) design process? *(Example: karma, etc)*

Regarding question (3), emptiness and interdependence are interchangeable concepts. The latter is used to describe phenomena in our daily life while the former is used to describe the metaphysical level of reality according to Buddhism. *Dependent origination* (or "dependent arising") is a concept that describes how emptiness occurs. Mitchell (2008) explains "dependent arising" in simple terms:

> This general principle of conditionality simply states that all things arise and pass away due to certain conditions. When necessary conditions are present to support a thing's existence, it comes to be. As those conditions change and new conditions appear, the thing changes. When the conditions for the thing's existence are finally removed, the thing ceases to be. This principle applies not only to the existence of phenomena but also to the quality of things." For example, the Buddha said that when certain conditions are present, *duḥkha* ["dissatisfaction" or "suffering"] arises. When those conditions change, *duḥkha* is modified. And when the conditions for *duḥkha* are removed, *duḥkha* itself ceases. (p. 39)

Since I knew that this is a key concept in the Buddhist worldview, and since I saw a parallelism between this idea and the engineers' need to think in the causes and

[45] In the original document, these words were written in Tibetan.

circumstances of a problem, I assumed that it was going to be a “culturally responsive” way to help them reflect on the causes and conditions of their chosen design problem. However, upon reflection I now think it was not the proper method to help them because I observed in my teaching that students did not understand the point of it due to language barriers, or perhaps because the concept is part of monastic education in their traditional view. In addition, I wonder to what extent they also may have resistance toward a form of teaching that connects “modernity” with something that they may perceive to be “traditional.”

Another component of my project was teaching lectures on elementary topics about sustainability and engineering. In the next section, I describe how I prepared myself before teaching the course.

4.5 Preparing to teach

To prepare myself to teach a culturally responsive introductory engineering course, I undertook two major efforts: To learn about the school and to learn about the students.

4.5.1 Learning about the school community

This section details the steps taken to learn about the school community. After arriving in India, I had to change school site, and therefore had to learn about the new school site, while editing the course content and interviewing teachers. I learned about the school through not only conducting interviews with participants, but also (a) observing classes to see how teachers and students interact, (b) observing after-school activities that were similar to engineering, and (c) visiting Tibetan communities outside of school.

I observed several classes to learn about the challenges that teachers have when teaching STEM topics to Tibetans, and how the students or teachers address them. Among the classes I was permitted to observe was a mathematics class taught outside of the classroom[46]. The teacher separated the students into groups of six to seven members. He assigned a trigonometric function to each group (sine, cosine, tangent, and so on). Each group wrote qualitative descriptions written in Tibetan about each function, and one student from each group presented in front of the class. The teacher explained to me that he wanted to encourage his students to understand the process and not just memorize the formulas. To help students understand difficult concepts in mathematics, he switched from English to Tibetan, and back to English. I also observed a physics class taught by an Indian teacher. When the class was over (and the teacher left the classroom), the students talked amongst themselves in Tibetan and referred to the physics book in an attempt to understand what was said in the class. These observations highlighted the significance for them of teaching and learning STEM topics in Tibetan.

During a mathematics class, I observed a student explaining a mathematic topic using hand gestures that reminded me of a Tibetan debate, a particular type of philosophical inquiry I discuss shortly. Later in the fieldwork, I observed that this student

[46] The teachers explained to me that sometimes they teach outside of the classroom to motivate more the students to learn the subject that they are teaching by changing the dull classroom environment. Sometimes it is also due to the high temperatures or lack of light when there is a power outage.

was particularly active in debate practices at the school. This observation led me to explore the ways in which Tibetan debate might influence how my students design and work in teams.

Perdue (1992) has conducted studies in the subject of philosophical debate in Tibetan Buddhist monastic education, and has described the purpose, preparation, and procedures of Tibetan debate. He indicated that debate is the main way of learning Buddhist philosophy in monasteries:

> [I]n the greater Tibetan monasteries the principal means of learning is debate. The monastery is the center of the Buddha's doctrine and a gathering place for those seeking inward peace and spiritual growth. In the monastery the sole purpose for study is to put the Buddha's teachings into practice in order to attain enlightenment. Great emphasis is placed on the knowledge to be gained through debate. Debate for the monks of Tibet is not mere academics but a way of using direct implications from the obvious in order to generate an inference of the non-obvious state of phenomena. The diligent debaters are seeking to understand the nature of reality through careful analysis of the state of existence of ordinary phenomena, the bases of reality. This is the essential purpose for religious debate. (Perdue, 1992, pp. 6-7)

The *preparation to debate* was summarized by Perdue (1992) as follows:

> One hears teaching on the topics of debate, this teaching often being given in the debating form. The one reads the text, memorizes the definitions and divisions, and on one's own thinks about the meaning of what one is studying. After this preparation one is able to debate the topic with others. (p. 7)

The *procedure of a debate session* involves two individuals: The Defender of a thesis and its Challenger (Perdue, 1992). The Defender "sits and gives answers to the Challenger" (p. 28) while the Challenger "stands and asks questions" (Perdue, 1992, p. 28) to him. The Challenger can also raises "qualms to the Defender's assertions and is not subject to reprisal for the questions he raises" (Perdue, 1992, p. 28). Books are not allowed in the debate courtyard of the monasteries; therefore, the individuals must be well prepared before debating (Perdue, 1992).

Perdue (1992) explained that the procedures of debate involve hand gestures, similar to the gestures that the student was doing in front of the other one when explaining a mathematics problem to him:

> Upon first seeing a debate, the most striking characteristic is the hand gestures. When the Challenger first puts his question to the sitting Defender, his right hand is held above the shoulder at the level of his head and the left hand is stretched forward with the palm turned upward…At the end of his statement the Challenger punctuates by loudly clapping together his hands and simultaneously stomping his left foot. Then he immediately draws back his right hand with the palm held upward and at the same time holds forth his left hand with the palm turned downward. This motion of drawing back and clapping is done not in two sharp movements, but in the flow of a dancer's movements. (p. 29)

He further explained the symbolisms of the hand gestures:

> Holding forth the left hand after clapping symbolizes closing the door to rebirth in the helpless state of cyclic existence. The drawing back and upraising of the right hand symbolizes one's will to raise all sentient beings up out of cyclic existence

> and to establish them in the omniscience of Buddhahood. The left hand represents wisdom which alone is able to overcome powerless cyclic existence, for the wisdom cognizing selflessness is the actual antidote to cyclic existence. The right hand represents method which for the Great Vehicle is the altruistic intention to become enlightened…The clap represents union of method and wisdom. In dependence on the union of method and wisdom one is able to attain the auspicious rank of a Buddha. (Perdue, 1992, pp. 29-30)

My initial observations of the influence of Tibetan debate on my students' teamwork were superficial (because I do not know Tibetan language). Through analysis of their reports, I discovered that my students' knowledge of Tibetan debate was limited, which is understandable because in traditional Tibetan culture those activities are part of monastic education and not part of modern (or contemporary) education. My group of students did not attend debate classes in middle school, as the current group of middle school students was receiving. However, the administration informed me that some high school students had assembled to practice Tibetan debate. Although my group of students did not have a strong foundation in Tibetan debate, I observed that they practiced other forms of debate (e.g., panels or forums at the auditorium where they exposed different views on Tibetan politics, the environment, and so on).

After school, I often observed students constructing a small incense burner next to the path that directs people to the main entrance of the school auditorium. They reused broken bricks and concrete. A staff member, who was in charge of the heavier construction phases, and a group of class 10 students[47] shared ideas for the design of the incense burner. A class 10 student explained to me that incense is burned for special occasions, such as when an important spiritual teacher goes to the school auditorium. From the way that he was describing the process and what I was observing, it appeared to be a form of informal engineering. This example is to help you see that, in school, children can be already doing informal engineering activities after-school, but some of them (like these Tibetan children) may not be able to develop cognitive connections between what they are doing and engineering, because of a lack of a teacher who can help them see the connections.

While in TCV Selakui, I visited two Tibetan factories in Rajpur (a town in the district of Dehradun, state of Uttarakhand, India), which is approximately one hour from Selakui. One was a noodle factory, and one was a welding shop—both owned and administered by Tibetans. I was granted access to the sites thanks to the assistance of the TCV administrators. Inspired by the work of Eglash (1997) and Greer et al. (2009), I took pictures of machineries and steps to make a final cultural product (e.g., Tibetan noodles in the case of the noodles factory and welded Tibetan Buddhist artifacts in the case of the welding shop) that are like the manufacturing steps in an industrial engineering setting. In an attempt to bring relevant content that they can relate to their familiar Tibetan communities, as a method of culturally relevant teaching, I included these photos in some of my presentations and I asked the students how these processes are like the processes to manufacture products in a factory, and how engineers need to understand these cultural ways to make food in order to transform them into industrial processes.

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[47] Equivalent to 10th grade in the United States.

4.5.1.1 Central Board of Secondary Education curriculum standards

Before the course started, some students approached me for college and career advice. Some students expressed the interest to study more than one major in college, such as biology and computer science, and English and biology. I began to question whether it was beneficial for the students to name the upper class (10+1 and 10+2) science course streams as "medical" and "nonmedical." However, I learned that this division was established by India's CBSE science curriculum standard, which the school adopted in order to help Tibetan students obtain a secondary school diploma that is acceptable to higher education institutions in India (Rigzin, 2003). At TCV Selakui, the upper class levels (10+1 and 10+2) specialize in the sciences; the school does not offer other specializations such as the humanities and commerce. Furthermore, I learned that students at TCV Selakui who want to study engineering choose the nonmedical stream.[48] Therefore it was important for me to learn more about the CBSE curriculum standards.

It was also important for me to understand how the standardized curriculum of a school site would impact the course directly or indirectly. For example, if the course content does not align with what the students are learning (or have learned), then the students may face difficulty learning that new content. In some cases, the legitimacy of, or the willingness of the students to participate in, the course would be affected by the competing commitments of a voluntary course and the required coursework.

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[48] For a list of courses taught per class level, refer to Table 2.2. in section 2.3.

Gupta (2007) explained the CBSE science stream division between medical and nonmedical:

> *The science course* includes the required or mandatory subjects English, physics, and chemistry. Students can then further opt for the:
>
> a. Medical stream within which the fourth subject required is biology, and the fifth can be either math or psychology;
> b. Non-medical stream within which the fourth subject required is math, and the fifth can be either computer science or economics [emphasis in original]. (p. 96)

A Tibetan mathematics teacher described the rigid curriculum of the CBSE. She explained that it does not allow for development of activity-based teaching, but she acknowledged that the school affiliated with the CBSE to assist students with admissions to higher education institutions:

> The school is affiliated under the CBSE, which is the Central Board of Secondary Examination of India. So, they have a very rigid curriculum for classes, especially from eight to ten. We have to cover that syllabus. We hardly get time to do activity-based teaching. We have two exams in a year; half yearly, and the annual exam. The CBSE prepares the questions paper and sends it to us. If we cannot complete the syllabus in time then it will be difficult for the students. They won't get good marks. When they go into colleges, the admission depends on the marks. It becomes very rigid for us.

A Tibetan mathematics teacher acknowledged the difficulty of applying certain teaching methods, such as group discussions and activities, in mathematics classes because the course syllabus must be covered to prepare the students to pass the CBSE exams:

> Those group discussions and practicals are very difficult to apply in higher classes [upper grades]. It takes a lot of time… We have a lot of syllabus to complete within a short span of time….Students need to prepare for the exam.

Worldwide, there is a debate on the benefits and drawbacks of standardized curricula and assessment methods (Liss 2013; Little, 1996). Teachers who implement an introductory engineering course in a school (regardless of geography) are bound to not only the school's policy, missions, and values, but also the curriculum standards that the school follows. Standardization of curricula has moved from a national level to an international level, as consequence of globalization and increased human migration (Liss, 2013). As Liss (2013) argued, because of global migrations, higher education institutions are relying on international standardized tests as a platform for students to obtain admissions:

> Because of this global movement of students, there is a greater need 'to legitimize their academic records with standardized tests, such as the SAT or ACT' (Zehr, 2006, p. 10). Consequently, test makers and some foreign countries are seeking to develop a single uniform platform for the college admissions process, one that will be a truly global system. This is to be accomplished through the use of standardized assessments, such as the SAT or the ACT, to be used throughout the world. (p. 563)

An effect of nation-wide standardized curriculum and assessment is that students are pressured to pass the classes with good grades or to memorize the content to pass tests.

Therefore, their school assignments take priority over an after-school (or extracurricular) class such at the one that I taught, which in turn impacts students' workload and your class schedule. For example, I frequently had to move the report deadlines and feedback sessions to accommodate to the school calendar of events because students needed the class time for other purposes (e.g., to assist with special events and to study for other classes). Sleeter (2012) summarized scholarly literature and reported that curriculum standards and culturally responsive pedagogy are not a good fit:

> As the work of teachers is standardized and pressurized, attempts to work with culturally responsive pedagogy become increasingly difficult. Teachers have less time to research and develop curriculum that students can relate to, nontested curriculum disappears under pressure to raise test scores, and teachers are increasingly patrolled to make sure they are teaching the required curriculum, at the required pace (Achinstein & Ogawa, 2006; Comber & Nixon, 2009; Crocco & Costigan, 2007; Gillborn & Youdell, 2000; Sleeter & Stillman, 2007). (p. 577)

Therefore, if a course is not part of the curriculum standards that the school must follow, then it becomes challenging to teach in a culturally responsive way and for the students to balance the assignments of required courses with those of an optional course.

4.5.1.2 <u>What instances of engineering are in their Science Day projects?</u>

It was important for me to learn what other instances of "engineering" and "design" existed in the school. In this way I could refer to these examples during class or interactions to associate my course content with familiar school activities. For example, I realized that the students participate in numerous teams at the school. Some teams are like "clubs" in that the formation is motivated by the students, but others are part of the school structure, such as *shenpen* groups.[49] I noticed that there were engineering-like activities in the welfare- and environment-themed *shenpen* groups and in the Science Day projects. At TCV Selakui, Science Day projects in the upper grades (10, 10+1, and 10+2) are not part of the CBSE standard. The school structures special events for each month, and one month is dedicated to science and students prepare science projects. The concept is similar to the science fair projects of schools across the United States, wherein students design a model to proof the veracity of a scientific principle or laws and teachers grade their scientific explanations in conjunction to their model. As a science teacher explained to me, each class (grade) is assigned a science topic:

> The projects are pre-decided by the science teachers. Before Science Day, they [teachers] have a brainstorming session with the principal, and they decide the topics and the project ideas.

Another science teacher described a year when the class 10+1 had to create Science Day projects based on the topic of alternative energies:

> Each class will get their own topic. For class 11, they got alternative energies: solar, wind energy, water, tidal energy, and all those things. For the whole month, they did a research...We took them to Energy Park in Dehradun. For an hour, they went by bus. They went around [the park], and learned other things. For example,

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[49] I describe these groups at the end of section 1.3.2.

Energy Park shows the efficiency of energy and how alternative energies can be used.

Many of their past Science Day projects can be categorized as engineering design as well. Several interviewees explained the different types of projects that students completed over the years; however, they did not have the means or resources to explicitly help the students understand why their work was similar to the work of an engineer. The following projects reminded me of engineering design: a solar cooker, a mini geothermal energy system connected by an electric turbine, a magnetic train, a model of a building with natural air conditioner, a food storage that does not need electricity, a hot air balloon, and an electrical *mani* wheel.[50] All of these examples were meant to apply scientific principles into design; therefore, I would argue that they also count as engineering even if they might not directly "solve" any problem identified at the school.

4.5.2 Learning about the students

Before going abroad, I assumed that perhaps I had stereotypes about Tibetan students based on what I (later in my analysis phase) learned was called an Orientalist (Said, 1994) view. Therefore, in my fieldwork, I purposely wanted to set aside the "mystical" perception of Tibetan culture, Tibetans, and Tibetan Buddhism. With that in mind, I dedicated time to interview teachers about the essence of Tibetan students, what

[50] A *mani* or "prayer" wheel is a ritual instrument used in Tibetan Buddhism. It features a cylindrical wheel attached to a spindle. Traditionally, a Buddhist mantra is written around the wheel.

challenges impact their STEM education, and how they might learn introductory engineering topics.

This section is divided into the following categories: (a) students' education is impacted by their refugee status, (b) stereotypes of Tibetan students, (c) students' interest in physics learning, (d) students' question about the ethics of biotechnology, and (e) learning mathematics in English.

4.5.2.1 Students' education is impacted by their refugee status

During the course of my fieldwork, it became increasingly important to learn about the political refugee condition of Tibetans in India. For example, several students in my 10+1 class were older than 18 years. A Tibetan teacher explained to me that those pre-adolescent Tibetans who cross the border with the intention to arrive to India, and who gain admission into the TCV school system, attend an "Opportunity Class," which is geared to identify a student's proper grade level based on his or her knowledge. She explained:

> Students who came from Tibet are placed in that special class [Opportunity Class], so they will be taught Tibetan, English, and Math. Within that year, depending on their progress, they will be sent to Class 2, 3, 4. So, they don't have to go to Montessori classes. They can jump straight to class 3, 4, or 5 depending on the progress they made.

Even though there have been few cases of Tibetans applying for Indian citizenship (c), the majority of the students are refugees (and therefore non-citizens). As a consequence, they are excluded from paying Indian citizens' engineering college fees (which generally are less than for non-citizens), employment opportunities, and other benefits that are bestowed upon Indian citizens. Furthermore, Tibetans in exile in India are divided in the debate about pursuing Indian citizenship (Moynihan, 2012a, 2012b) as well as the best political status for Tibet: either total independence from China or the "Middle Way" approach (Norbu, 2013).

Because of the complexities that arise in the politics of displaced populations, foreign teachers going abroad should learn about not only the people's culture (as argued by Grimes, 2010), but also how to honor the cultural identity of a student. Special consideration should be placed to avoid actions that transgress the cultural or ethnic identity of a person. Sometimes a teacher performs actions that can affect the relationship between the foreign teacher and a student, even if that was not the intention. For example, after I realized that I would not be able to teach in Norbulingka Institute, I presented my project to the students at Kunpan Cultural School in Dharamsala, before presenting it to the students at TCV Selakui. Although I was aware of the politics between Tibetans in exile and China, I was nervous when I was presenting in front of students and I committed the mistake of asking, "Do you all come from China?" The students were clearly offended, and I apologized. This was the most tense situation during my fieldwork, and serves as an example of how these type of identity-related offenses can strain the relations between a teacher/researcher and local students.

4.5.2.2 Stereotypes of Tibetan students

Geneva Gay (2000) stated that all teachers have biases and stereotypes about the "others" (i.e., people from different ethnic and/or racial groups). She argued that multicultural teachers should take time to learn about the sociocultural and individual differences in students that might influence their learning styles:

> In examining learning styles, it is important to remember that how, or whether, they are expressed by individual members of ethnic groups is influenced by other variables. Critical among these are level of ethnic affiliation, social class, education, and degree of traditionalism. (Gay, 2000, pp. 147-148)

Tibetans are portrayed by some Westerners as a collectivist culture, which would lead to the assumption that all students will favor collectivist learning over individualized learning. However, before the course started, I observed at the school site students who were more comfortable studying alone and students who were more comfortable studying in a group. As a result, I updated my understanding about Tibetan students' preferred learning styles: Not all prefer collectivist learning methods at all times.

When interviewing Tibetan teachers, I asked if they noticed differences in Tibetan students from Tibet and those from India. Teachers described Tibetan students from Tibet as (a) having higher aptitude for mathematics, (b) being more hardworking and respectful, (c) being over-aged for their school class, and (d) facing more difficulty to adapt to the new languages (Hindi and English) and the accents of Tibetans who were born and raised in India.

I received contradictory reports about how Tibetans in temperament and character are *in general*. No matter their birth place, ethnic Tibetan students were perceived by teachers as (a) calm, (b) not very outspoken, (c) kind, (d) needing clear instructions, (e) possessing low self-confidence, (f) lacking skills to plan their future career, and (g) interested in computers, science fiction, and the connection of science with Buddhism.

The students' responses to the pre-course questionnaire were varied. One male student said that Tibetans quickly get angered: "I consider that Tibetans in Tibet are kind and simple, as well as peace-loving by nature. One bad thing is they have a short temper. They quickly get angered. They love praying." Other students described Tibetans in terms of nationality, genetics, religion, and difference from Chinese. For example:

> "Tibetans are the people who are born to Buddhism by religion and capable to do anything."
>
> "To be a Tibetan means a different nationality from Chinese and the person should not be cruel, or killing animals, etc. Also the person should have humanity."
>
> "I am happy and satisfied to be a Tibetan, even though we lost our country to China in 1959. We have a unique religion and beautiful history… I'm lucky to be a follower of His Holiness the Dalai Lama."
>
> "Genetically belonging to Tibetan parents. Having the blood and genes of the Tibetan race."
>
> "Calm, tolerable, helpful, hardworking, true believer, someone who knows his responsibility at large universal responsibility."

I argue that these diverse portrayals of Tibetans reflect the contemporary multiculturalism in Tibetan society in exile. Other scholars have noted multicultural practices among Tibetans in exile (MacPherson & Ghoso, 2008). They observed that recently arrived Tibetan female youths in Toronto, Canada, retain multicultural practices in their daily lives, a reflection of the multicultural reality that some Tibetans experience in India:

> During our onsite community ethnographic observations, for example, it became apparent that this multilingual and intercultural experience has affected the cultural life of the individuals and the local Tibetan community, who are as likely to performs Hindi songs and dances as Tibetan songs and dances in public performances, or eat *dhal* and rice with spice *chai* as consume *momos* (Tibetan dumplings) with the traditional Tibetan salt-butter tea or *Pho-cha*. (MacPherson & Ghoso, 2008, pp. 197-198)

Furthermore, because of globalization and migration to other countries, Tibetans have appropriated words and cultural practices of their host country, Western culture(s), and in cases of multiple migrations, their previous host country. As Bentz (2012) argued:

> Relations with the homeland (not to mention the home country) and with the host country can be analysed from a communitarian perspective, but one should also keep in mind that there are individual differences within the refugee/diaspora community. The Tibetan exile community is no exception. It can present itself (and, more importantly still, be seen as) strong and united, and still remain heterogeneous to some extent. In other words, no matter how much emphasis is put on unity, diversity is there and can sometimes be seen as prevalent. (p. 100)

Although Tibetans share a culture, teachers must be cognizant of both the individual differences based on personal identities, and the multicultural realities in which they live or have lived. Every ethnic group from a distance might be seen as "homogeneous," but after working or living in a relevant community, we realize that in fact diversity exists in every ethnic group. Sometimes the individual characteristics and interests become stronger than the collective characteristics. As Van Cleave (2001) found when developing a culturally relevant computer science and engineering curriculum in a Native American tribally-controlled community college in Minnesota: "The extreme diversity of beliefs among the Indian students created difficulty in determining which activities were 'culturally relevant,' since what some considered comforting and comfortable, others found intolerable" (p. 55). Therefore, culturally responsive educators must balance both the individual and collective factors that influence students' learning styles.

As an example of the partial influence on students' individual interests by cultural leaders in Tibetan society (such as the Dalai Lama), the next section discusses the interest of some Tibetan students (specifically in TCV Selakui) in theoretical physics.

4.5.2.3 Students' interest in theoretical physics

Before I started my teaching, I knew that the spiritual leader of Tibetan Buddhism, His Holiness the Dalai Lama (HHDL), has frequently engaged in dialogues with physicists, neuroscientists, economists, and psychologists on the qualitative relationships between the sciences and Buddhism, especially through the Mind and Life Institute

(2014). From my observations, these dialogues are an amalgam of Buddhist modernism[51] and scientific positivism. Although HHDL is no longer the political leader of the Tibetan people in exile, he still exercises a powerful influence on some Tibetans, and his views on Buddhism and science (under a positivist paradigm) may influence some Tibetan students to become interested in the sciences.

Whalen-Bridge (2011) explained how these dialogues are influencing contemporary secondary education of some Tibetans in exile:

> *The Universe in a Single Atom* specifically contests this construction of modernity and it is part of a comprehensive, coordinated discourse. There have been dozens of Mind/Life Institute meetings since the first one in 1987, and these dialogues between representatives of contemplative practices (especially the Dalai Lama) and scientific students of cognition and neurobiology (such as world-class expert on human emotions, Paul Ekman) have produced a rich stream of publications that range from the more academically rigorous kind of research to popularizing texts designed to help people change their lives, e.g. Daniel Goleman's *Emotional Intelligence* (1997). In addition to the speculative and summative dialogue sessions, the Buddhism/science conversation is being made part of monastic training and is directly promoted by the three modernist-monastics under discussion, Dalai Lama, Geshe Lhakdor and Samdhong Rinpoche. With the assistance of foreign universities, especially Emory University, science courses are being taught in a number of Tibetan Buddhist monasteries. This de-

[51] Donald S. López (1998) argued that the term "Buddhist modernism" was coined by Heinz Bechert "to describe tendencies that began in the late nineteenth century when monastic elites in Sri Lanka and Southeast Asia sought to counter the negative portrayals of Buddhism by colonial officials and Christian missionaries" (pp. 184-185).

> segregation of what typically is called secular knowledge and spiritual training is taking place throughout the Tibetan-speaking world, even at the level of secondary schools. (p. 110)

Regarding this last sentence, the principal and several teachers at TCV Selakui told me that students had been exposed to some Mind and Life Institute dialogues between HHDL and scientists through videos presented in the school auditorium. In my literature review, I did not find research on how (a) the authority of HHDL's perspective on science, (b) the Western discourses on modernity and development, and (c) scientific positivism in the Indian contemporary school curriculum (which take effect in Tibetan schools in India, mostly at secondary school) influence some Tibetan students' interest in the sciences and engineering.

During my fieldwork, as part of my exploration of both research questions, I wanted to probe whether or not many Tibetan students in TCV Selakui liked physics because they had seen HHDL engaging in Buddhism and science discussions, and physics is a subject taken by engineers. Two school staff members informed me that the students like to read science fiction, and physics teachers observed that some students (in my findings, mostly male) are interested in topics about theoretical physics. According to an Indian physics teacher,

> They talk a lot about that [theoretical physics]. They tend to talk a lot about quantum theory and relativist theory, which they don't really understand, but they talk a lot about them. So, I believe yes they are interested in those kind[s] of things.

The same teacher believes that these students are interested in theoretical physics because their Buddhist abstract background resonates with the abstractions of theoretical physics:

> Many of them are really interested in it [theoretical physics], and probably that is some influence of Buddhism, you know.… I'm not that good in Buddhism, but I think it's abstract, just like most of the Eastern philosophies, very abstract. So, abstract thinking is integrated in [their] genes, you know…. It could be possible.

In the pre-course questionnaire, my students responded to the questions "What is your favorite field of study" and "How has Tibetan Buddhism helped in your life?" Some identified science (especially physics) and Buddhism. Table 4.1 presents the responses of students who responded with physics, science, or the relationship between Buddhism and science:

Table 4.1 Students Who Wrote about Their Interests in Science, Physics, or the Relationship between Buddhism and Science

Question	Response
What is your favorite field of study?	"Quantum computer science. I'm attracted towards programming the universe." (Male student #2) "The relation between science and Buddhism. Because I am a Buddhist as well as scientist." (Male student #10) "I like to study science and Buddhism. Buddhist philosophy helps me to think critically and, through science, I can learn the logical discoveries." (Male student #22) "If I am not thinking of studying engineering, then I am interested in Buddhist science. Because since I was in lower class [grade] I like to study Buddhist science." (Male student #28)
In which areas of your life has Tibetan Buddhism helped you?	"In being compassionate,[52] in widening the circle of love,[53] in healing anger,[54] and in a way the relation between Buddhism and science." (Female student #8) "….I think it will also help me to study astrophysics and quantum physics as there is a deep relation between Buddhism and those fields." (Male student #13) "I contemplate on Buddhist philosophy, Buddhist science, and Buddhist tradition. Our teacher, His Holiness, has been [illegible] dialogue with scientist from all over the world." (Female student #33)

These findings do not imply that TCV Selakui students are more interested in physics than in engineering. Most of the students who took my course were in the nonmedical stream that has a greater focus on computers and engineering (although four

[52] "Being compassionate" connects with the virtue generosity.
[53] "Widening the circle of love" can be interpreted as an attribute of the virtue perseverance.
[54] "Healing anger" is an effect of the virtue patience.

students were in the medical stream). The questionnaire responses also reflected a strong interest in health-related careers, which was confirmed by school administrators and teachers. Of the four students in the medical stream, three were female students (out of eight female students in my class). Scholars have noted girls' preference for health-related careers rather than careers in engineering or "hard" sciences, because both "women" and "medical degrees" are associated with the role of caring[55] (Tonso, 2007).

As discussed in Chapter 5, traditional Buddhist societies have constructed adequate roles and practices for Buddhist monastics and Buddhist laypersons. In this case, another layer of factors should be considered: What do their religious leaders or elders think about science and engineering? How does the authority of these religious leaders and elders impact the students' likelihood of being interested in the sciences and engineering? In the case of Tibetans in exile, HHDL has embraced the sciences, but what if we want to teach this course to other Buddhist groups whose religious leaders are not open to scientific knowledge? These issues should be considered before teaching introductory engineering using this educational approach. Because emotions play a powerful role in learning (Bower, 1992), it is better to understand beforehand whether one's course will be accepted in another Buddhist-influenced society, especially in a traditional Buddhist society.

In summary, any religion, including Buddhism, does not have a universalized interpretation and experience. Before developing a curriculum that combines culturally responsive pedagogy with a religion, for a different cultural group from ours, we have to be careful of not developing a curriculum based on our individual Western (or even

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[55] From a Buddhist perspective, the role of caring can be associated with the virtue generosity.

Orientalist) interpretation and experience of that religion because it might be inaccurate in our students' experiences of that religion, that can be tainted by a complex interrelation of it with local and foreign politics, nationalism(s), social classes, gender roles, colonialism(s), and historical processes.

4.5.2.4 Some students question the ethics of biotechnology

According to a Tibetan science teacher at the school, students sometimes pose questions about the ethics of biotechnology when the teacher talks about microorganisms and in vitro fertilization. She explained:

> When we talk about in vitro fertilization, there's a fusion of two gametes. Usually when we discuss about that, we say that these are zygote formed outside the body, that is in a laboratory condition. Four or five are kept and then, well the most suitable one will be implanted. The rest will be discarded. Soon after the formation or the fusion of gamete, of course, the body will be formed after cell division. But, at the same time there is, how do you say? Soul. A soul is also incorporated there. So, they [students] say: "What about the soul? It will be killed." So, they talk about sins and all those things.

Notice that the students were concerned about what would happen to what she called the "soul"[56] of the zygote after the scientist kills it. As she has encountered, these

[56] I believe that "soul" is her translation of what English translated Buddhist texts call "mindstream."

beliefs in *karma* and rebirth[57] may lead some students to pose questions about life and death.

These are challenging questions that science and engineering teachers must address when they introduce topics that might clash with their students' beliefs. The students were concerned about the life of the zygotes because in their morality killing creates a negative form of *karma*. Issues such as these must be understood in the cultural context, and teachers must to be prepared to address the questions that arise when moral principles conflict with what we teach in a science class (that might be relevant to engineering as well).

Another example of how culture impacts the learning process can be found in the experiences of the Tibetan students learning mathematics in English.

4.5.2.5 Learning mathematics in English

When I was starting my fieldwork, I learned from school administrators that a high-priority need of the Tibetan society in exile is qualified Tibetan teachers, not only to preserve Tibetan language but also because the students learn better in their native language. I observed that they are more comfortable and fluent speaking in Tibetan. They even acknowledged that a course taught by a Tibetan engineer would have been more effective than one taught by a Western engineer.

[57] "*Karma* and rebirth" is associated with the virtue morality because Buddhists believe that accumulating positive actions will lead to a better rebirth.

Two teachers spoke about the problem of teaching mathematics in English. Within the TCV School system, it is in class 6, in middle school, when teachers transition from teaching mathematics in Tibetan to English. To support the students during the transition process, the teachers switch between English and Tibetan. From the teachers' perspective, the student outcomes are better when they learn concepts in Tibetan:

> "In the local classes, like class 6 and 7 we face a lot of problems translating, you know, every term back to Tibetan because they are learning English for the first time."
>
> "I find that it's less effective to teach mathematics in English, in my class, compared to using our first language. Because, first of all, they don't understand the math concept, plus they will be confused with the English."

Scholars have reported on code-switching (when a person alternates between languages) in multilingual mathematics classrooms and the challenges faced by students learning mathematics in English. For example, Setati (2002) explained that in multilingual mathematics classrooms in South Africa, code-switching is generally used to help the students. Setati (2002) confirmed that mathematics taught in the native language tends to be more effective. The student does not have the cognitive load of trying to understand mathematics terminology and English syntax in English at the same time as the logic of mathematics (Brodie, 1989; Durkin & Shine, 1991; Galligan, 2001). Therefore, it is understandable why Tibetan teachers' code-switching in mathematics is an effective way to help Tibetan students learn this subject.

In the next new section, I begin a new theme: Gender-related considerations when teaching Tibetan students, which emerged during analysis of my fieldnotes and reflections and caused me to revise some of my assumptions about teaching to Tibetan girls.

4.6 Gender–related considerations when teaching to Tibetan students

I did not include gender-related considerations in my course design, but during my fieldwork I experienced difficulty communicating and assisting female students. This was surprising because I assumed that the girls would be comfortable talking with me as another female. However, our differences in language and sociocultural backgrounds inhibited the ease of our interactions. This experience led me to realize that gender is not the only factor that determines effective teacher-student interaction: the students' perceived differences in the language and cultural backgrounds of the teacher also play a role. From the students' perspective, are they confident enough to speak in English? How are their perceptions of Western female teachers influenced by their Occidentalism (Carrier, 1992, 1995)? From my perspective, I acknowledge that my lack of confidence when talking about STEM careers with female students (resulting from my withdrawal from STEM careers to pursue a different career path) likely diminished the effectiveness of my communications.

This section discusses what I experienced when teaching Tibetan girls. Teachers can benefit from my experiences and knowledge, which in turn can help them to become socially just as well as culturally responsive in their teaching practices. Three themes emerged from my analysis: (a) difficulty communicating with Tibetan girls, (b) proper responses when students laugh at girls' scientific explanation of their engineering design, and (c) medical and nonmedical streams in high school.

4.6.1 Difficulty communicating with Tibetan girls

Teachers at the school argued that girls tend to be more hesitant than boys when they approach a Westerner. A Tibetan teacher said the following about students approaching foreigners:

> Girls feel shy. Boys they are very open. I think that is a really big problem for our Tibetan students… Even with their sponsors [they are shy]… So, it's difficult for them to speak, even with their sponsors.

This teacher's opinion was also echoed by other Tibetan teachers, including a science female teacher with whom I had numerous informal meetings. She explained to me some of her students (mostly girls) are shy about raising their hands because they fear that others will make fun of their participation in class. Slavkin (2001) studied the relationship of personal gender roles and self-esteem of 48 early adolescent girls enrolled in a summer program. Under an ecological systems theory perspective, he found that "perceptions of gender and self-esteem, along with the behavior setting of a group activity, do affect the behaviors of early adolescent participants and their interactions within groups" (p. 264). Tibetan students' participation in class may be influenced by the degree of encouragement that they receive from their peers and teachers, in addition to their perceptions of their gender roles in a particular classroom setting or group activity.

During the feedback sessions, it was difficult to ascertain whether or not girls were having difficulties in teamwork. For example, during a feedback session, I asked Team 4 (two girls and two boys) how they were handling their teamwork (i.e., whether there were any issues). I had a feeling (from their reports and observations) that they were having difficulties agreeing on the problem to select. However, the students were not comfortable sharing their experiences with me, mostly likely because in their culture preserving group “harmony” is more important than voicing individual concerns. In addition, members from other teams were also in the classroom—this was not a private venue. The fact that I consider myself a Buddhist did not change matters because, above anything else, in their view, I am a *Westerner*.

The observations laid out in the next chapter could also shed light on lack of female participation in the classroom.

4.6.2 What can you do when students laugh at girls’ scientific explanation of their project?

This theme emerged from observations about the students’ reactions during final project presentations in the school auditorium. I had one all-girl team: Team 7. During Team 7’s presentation about their rat trap design, the audience behaved as they did for the rest of the presentations, up until the “physics concepts” slide at the end. As a team member explained the physics concepts related to the design of their rat trap, the audience laughed more intensely at her explanation than the other teams’ explanations. This behavior was so disruptive that the staff members and I had to silence the audience.

The girl explained how the rat trap worked in a serious way, but the audience didn't take her explanation seriously.

I observed (from this and other events on the school auditorium) that female students and shy male students often faced more laughter than other students. Similar to my observations, Lahelma (2002) studied the behavior of girls and boys in a secondary school in Finland to understand the boundary between what was experienced as harassment and what was experienced as fun. She observed that girls were more targeted in situations that could turn into harassment while boys were more targeted because they did not show a proper amount of masculinity:

> Girls are vulnerable because they can be insulted at any moment by sexist commentaries, and "any moment" could be a situation that has started as play-acting and joking and can be turned into harassment. To react powerfully and negatively against what is "just joking" is to show oneself to be humorless (Larkin, 1994; Phoenix, 1997). Sex-based harassment acts, nonetheless, as a form of social control, and hence has material effects on all girls and women, including those who have not experienced it personally (cf. Kenway & Willis, 1998). Some of the young boys' vulnerabilities, on the other hand, leave them open to being called "homo", and also of not being seen as being able to learn "to take" bullying from their peers (Phoenix, 1997), especially from girls. Boys are not harassed because they are boys but because they are the *wrong* sort of boys. This kind of sex-based harassment builds hierarchical differences between boys, between masculinities, in which heterosexual masculinity is superior [emphasis in original]. (p. 302)

I am not sure what factors determine the outcomes of being the target of such behavior, for example, perhaps lower self-esteem or motivation to strengthen character. From a special education perspective, however, I am particularly concerned if the behavior is targeted to students who knowingly or unknowingly suffer from post-traumatic stress disorder (PTSD) as an effect of their refugee condition, because evidence of PTSD symptomatology has been found in Tibetan children in India (Servan-Schreiber, Le Lin, & Birmaher, 1998).

When I heard the laughter, I asked myself, "Should I stand up and try to silence the students or should I stay seated while silencing them from here?" Meyer (2008) studied teachers' non-interventions to gender harassment in a Canadian context and found that most participants "spoke of their personal desire or commitment to challenge issues of gendered harassment but felt limited in their actions due to a perceived lack of support from the administration and their colleagues" (p. 567). In my case, throughout my intervention I observed that Tibetans display discomfort when asked questions about gender differences. When this incident happened I felt a strong tension in me: I knew that I should stand up and do something about it, but I had already observed that pointing out gender differences is not accepted at least in this school context. Therefore, I joined the other staff members who were trying to silence the students from their seats.

We can shed light on this behavior in the school auditorium if we examine the perception of masculinity in Tibetan culture and the Western culture perception that the "hard sciences," such as physics, are "masculine" (Kessels, Rau, & Hann, 2006). Hillman and Henfry (2006) published a study about the perception of Tibetan masculinity according to Tibetans and Chinese. Tibetans described a "real man" as "'frank,' 'loyal,' 'tough,' and 'courageous.'" (Hillman & Henfry, 2006, p. 261). Hillman and Henfrey (2006) explained that this construction of masculinity was needed in order to function in the nomadic environment from which the majority of Tibetans originally came.

If the students believe that masculine person is bold, courageous, and decisive, then it is no surprise that prototypically feminine females and shy boys who do not project these characteristics are the subjects of laughter when they discuss topics that are considered masculine. Therefore if you are not sufficiently masculine according to Tibetan cultural standards, then you might not be well suited to the task of explaining masculine topics such as physics. Of course, this might be a subconscious association that students are not aware of.

Connell (2002) argues that psychologically we combine feminine and masculine characteristics and that our cultural background defines gender patterns. I am sure that the TCV students were not conscious of the association of physics as a "masculine" subject. It seems to me that their laughter was the effect of "cognitive dissonance" (Festinger, 1957). Lindsay (2014) explained:

> When one is faced with the tension of dissonance, basic dissonance theory states that the typical human reaction is to attempt to reduce or resolve the inconsistencies present in one's beliefs or behaviors. . . . According to Festinger (1957), one might change one's belief or behavior to resolve tension, one might develop new cognitions that reduce tensions by rationalizing the inconsistency, or one might devalue the importance of the inconsistency. (pp. 98-99)

The devaluation of the perceived inconsistency can take the form of humor (Lindsay, 2014). In the incident in the auditorium, the students observed a female student explaining the physics of a rat trap and experienced cognitive dissonance. They resolved the tensions through laughter. I question how different the results would have been if I been able to help to rationalize and feel empathy about the situation.

Based on my observations and previous research cited above, I assume that students facing the laughter of others will likely experience a negative association between self-esteem and the situation—if the student interprets the laughter as hostile—especially those students who consider the school community to be like a big family. More research is needed.

4.6.3 Medical and non-medical streams in high school

From the school administrators and teachers, I learned that Tibetan girls in TCV Selakui often choose the medical stream over the nonmedical stream in high school (see section 4.5.1.1 for an explanation of why the streams happen in high school). Only two TCV schools offer science streams—TCV Selakui and TCV Bylakuppe (in southern India). I do not have information about girls' selections at TCV Bylakuppe, because in my fieldwork I did not inquire about female and male tendencies towards choose one stream over the other in that school.

One teacher thought that girls opt for the medical stream because they feel “more comfortable” with that stream, while a Tibetan engineer cites friends’ influence as the reason:

> I think girls are more comfortable in that line. I don’t know why but here in our school it is like that. Most of the girls opt for biology and most of the boys opt for mathematics or engineering line. (Tibetan teacher 5)

> For example, [they think]: “My friend is going to nursing course.” Then, next they start to [say]: “Oh, you are going [to nursing school], then, I’m also going with you!” (Tibetan engineer 1)

This gender segregation in career selection has been explained in education research. Scholars have argued that students need to develop a sense that they belong to a professional community in order to decide to study a major (Hsu & Roth, 2010). Hsu and Roth (2010) studied the phenomenology of belonging to a scientific community in high school students who participated in an internship with technicians. They found that the technicians’ dedication with the students helped the students to develop a sense of belonging to a scientific community:

> The students recognized that they were provided as many opportunities as the technicians to practice scientific work and even had equal status to the technicians. Although the students sometimes had difficulty understanding some complex concepts or terms, the technicians usually spent time and effort for discussion and exchange of ideas. The open conversation and interaction facilitated the students’ sense of belonging and ownership in the science community. (p. 300)

From my participants' responses and my observations, I assume that female Tibetan students opted for nursing because of a complex combination of factors: (a) their expectations of which careers have more demand in Tibetan and Indian societies, (b) their parents' influence, (c) the association of women and nursing with the notion of caring (Poole & Isaacs, 1997), and (d) the influence of their collectivist culture that favors keeping a bond with friends and family over having an independent life. More research is needed to understand why some course streams are favored over others.

It is important for teachers to understand these gendered career selections because they could be a reflection of the culture, politics, curriculum structure, and gendered norms of the societies in which the students live—in this case, Tibetan, Indian, and possibly others as well. These factors will also affect the acceptance or effectiveness of a course such as the one that I offered. All educators have the good intention to provide an equitable and socially just space for girls and boys to participate in a course, but what happens when girls and boys have already opted for a course stream—and therefore their future career path—and have no way to change that stream? Or what would happen when the politics or cultural taboos do not encourage noticing the gender differences between boys and girls? These factors will impact girls' decisions whether or not to study subjects traditionally considered "for boys" or, vice versa, boys considering subjects traditionally considered "for girls."

The next section focuses on my students' observations about the course and my teaching methods. By examining my students' feedback from the post-course questionnaire, I was able to identify areas in the course content, my teaching, feedback sessions, and design project that should be improved, if a similar course were to be implemented again.

4.7 Summary of my students' course feedback

Questions 14 to 23 of the post-course questionnaire provided the options "yes," "no," "partially," and "unsure" (see Appendix Q). In addition, a blank space allowed the student to write the reason for his or her response (what I call "in-depth responses"). From the in-depth responses to the following questions, I was able to identify the themes presented in sections 4.7.1 and 4.7.2:

- Did the *course [content]* fit your expectations?
- Did the *way of presenting the course* content fit your expectations?
- Did the *course project* fit your expectations?
- Did my *feedback sessions* fit your expectations to help you in your project?
- What do you think of the *way I connected engineering with Buddhism*? (example: when I mentioned dependent origination, the six perfections (virtues), interdependence, systems thinking and emptiness)
- What do you think of the *way I connected engineering with examples relevant to your culture and surroundings*? (example: when I connected engineering with (1) the processes to make *tingmos*, (2) the processes to make *dorjees* in a metal-workshop in Mandwala, (3) paper recycling at the school, (4) the steps to make noodles in a factory in Clementtown, (4) photos of the school where

structural components can be identified, (5) sustainability and photos of nomads and other Tibetans).

- Any other comments to me?

In section 4.7.3, I identify the students' recommendations from the following questions:

- What information would you *add* in the course content to be more helpful to Tibetan students?
- What information would you *delete* in the course content to be more helpful to Tibetan students?
- What information would you *correct* in the course content to be more helpful to Tibetan students?
- Any other comments to me?

All questions were voluntary. If a student wanted to provide a reason for his or her "yes," "no," "partially," or "unsure" answer, then he or she could write a response in the blank space provided. I treated some of their partially and unsure answers as a "no," based on what they wrote. I believe that the students approached the questions this way because it is more polite in their culture to say "partially" or "unsure" than "no." Some students left the commentary lines blank, but they circled "yes," "no," "partially," or "unsure" without providing an in-depth response, or skipped questions.

I analyzed the feedback by student (not grouped by team) to develop a sense of the overall feedback. I separated my analysis into the following categories: (a) course content, (b) teaching, (c) course projects, (d) feedback sessions, (e) culturally responsive approach, (f) connection between engineering and Buddhism, and (g) their recommendations, which mirror the structure of the questionnaire. Each category, except "their recommendations," "connection between engineering and Buddhism," and "culturally responsive approach" has the subcategories: (a) what they appreciated and (b) their concerns.

I used thematic coding to group those students' responses which had the same theme. The theme count appears in the right column of tables 4.2 to 4.13. Each response usually had one theme. I paraphrased the majority of the themes. Direct quotes from the data appear within quotation marks.

4.7.1 Course content

Table 4.2 Reasons Why the Course Content Fitted their Expectations

I gained knowledge about engineering.	**6**
I saw that engineering can also be "simple" (not "hard").	**3**
It featured a hands-on activity based on a real problem.	**3**
It talked about the connection of engineering and society.	**3**
It was inspirational.	**2**
You showed videos that connected to the real work of engineers.	**2**
It is what "I hope to study."	**1**
Because "I like engineering."	**1**
It had a sustainability component.	**1**
I got the information that I expected.	**1**

Table 4.3 Their Concerns About the Course Content

"Because I expected more to learn from you."	**2**
"[The] most important content [is] already known."	**1**
"I thought [that] the course [was going to] be very complicated with a lot of familiar calculations and notions also."	**1**
"Because I would [have] liked to listen more about computers from you."	**1**
"I see that such things [engineering] are unnecessary."	**1**

In summary, the students appreciated that the course offered information about engineering and that they were able to work on a hands-on design project. They appreciated that I presented a simplified version of what is engineering and it helped them see that engineering is not always to design big and complex things. In addition, there was an inspirational component to it. Furthermore, they appreciated that I brought content that connected to society, sustainability, and that it showed the "real" work of engineers.

Students shared many concerns with me, which I attribute to their Occidentalism (Carrier, 1992): Their perception that peoples from the West have "superior" knowledge, development, and expertise. Perhaps, because I presented myself as a person with a background in computer science, they thought that I was able to talk more about computers. Some expected a course with complicated mathematics and physics calculations. One student shared that he thinks that such things (engineering) are not necessary. Perhaps importantly, this student came from Tibet. Perhaps from where he came from, engineers are not really that necessary in his former communities because there are other individuals with similar knowledge (e.g., carpenters and artisans) that play the role of what is considered an engineer in contemporary society.

4.7.2 Teaching

Table 4.4 Reasons Why My Teaching Fitted Their Expectations

It was “organized” (or structured) well.	**5**
Because you gave printed-out copies of the lessons.	**4**
The presentations were “easy to understand.”	**3**
“[I]t was compared to our Tibetan way of life.”	**1**
You gave a copy of project guidelines.	**1**
Because you showed interesting presentations.	**1**

Table 4.5 Their Concerns About my Way of Teaching

Dull lectures.	**3**

In summary, the students thought that my course was well organized. They appreciated a lot that I gave them printed-out copies of my electronic presentations. Some thought that my presentations were easy to understand, presumably because I added more photos related to the content. One student appreciated my teaching method because I showed how the ways of living of Tibetans have aspects that are like engineering. Finally, the students felt that my lectures were dull, in part perhaps of my character and because I am soft-spoken.

4.7.3 Course project

Table 4.6 Reasons Why the Course Project Fitted Their Expectations

They gave us the experience of design.	**2**
We noticed that our school has many problems that we can solve.	**2**
It helped us to see that simple projects can also be innovative.	**2**
Because of the sustainability component.	**2**
Because what we designed was successful.	**2**
“I was expecting something unique.”	**1**
It is the job I wish to do.	**1**
It made me feel like an engineer.	**1**
The experience helped me to understand “how engineers come up with [a] solution.”	**1**

Table 4.7 Their Concerns About The Course Project

Lack of time to work on our project.	**4**
The project was not successful as we expected.	**2**
Because we had to change our project theme.	**2**
“I needed to learn more on energy[a].”	**1**

[a]This is an ambiguous response to me. Either he/she was reflecting that he/she needed to learn more on energy to come up with a successful design, or perhaps he he/she was indicating that I did not provide enough information on energy.

In general, the students appreciated the design experience because it helped them to see that they can also innovate through simple projects and that the school has many problems that they can solve. They appreciated the sustainability component. Two students valued the design project because they felt that their projects were successful. There was a sense of belonging component as well because one student felt “like an engineer.” One student felt that the design project gave him insights on how engineers come up to design and create things. One student was satisfied with what he experienced because he expected a unique or novel design project. Finally, one student liked the design project because of his interest in engineering.

Their main concern was that they lacked time to do their projects because it was an extra-curricular course. Two students, both members of Team 6, felt that their project was not successful. I believe that they said so because when these students presented their project at the school auditorium the design did not work as expected.[58] Two students, both part of Team 8, expressed frustration that their project theme changed during the course. This team had a lot of difficulty undertaking the project.[59]

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[58] Refer to section 6.7 of chapter 6 for more information.
[59] Refer to section 6.8 of chapter 6 for more information.

4.7.4 Feedback sessions

Table 4.8 Reasons Why the Feedback Sessions Fitted Their Expectations

They helped us to "shape" or "correct" our designs.	**7**
They gave us a sense of direction.	**5**
They gave us or provoked new ideas.	**4**
We got the chance to have a dialogue with you that helped us to change our design.	**2**
They eased our work.	**1**
They helped us to "improve our reports."	**1**
They helped us to clear out doubts.	**1**
They reminded us what we are learning.	**1**
They were like a "friend [who tried] to help me."	**1**

Table 4.9 Their Concerns About The Feedback Sessions

Sometimes your instructions were not clear due to language barriers.	**2**

In summary, they thought that the feedback sessions were useful to help them change or correct features of their design. Also, they thought that my way of helping them gave them a sense of direction. One student thought that I was able to help them gain more confidence (self-efficacy) that they were going to be able to accomplish their goals. One student thought that the sessions reminded them of what they were learning. One student thought that my help was like a friend's help. Note that one student thought that the sessions were helping them to improve their reports; a response that made me think that some of them might have focused more on answering reports rather than designing them. Finally, their major concern was that some were not able to understand my instructions because of the language barriers.

4.7.5 Culturally responsive approach

In Table 4.10, the shaded rows indicate the general theme and the indented text below each shaded row are the students' quotes associated to the theme. I decided to show the students' quotes in this table because their responses were more complex and had to do with one of the core components of the course. The italics indicate the part of the quote that I used to define the theme.

Table 4.10 What they thought about the culturally responsive approach

It made us see that we can make changes in our community.	**4**
"It's really amazing that *we can do changes in our own small surroundings* and *bring better changes to our own culture* which was for generations, everyone has been following. Engineering can innovate regarding our old ways."	
"This was inspirational to us, that *we Tibetans have a lot to do* and the engineers have a lot of jobs to be done. I had also realized during that time *I had thought of inventing something new to solve time consuming things*."	
"The way that you connected engineering with examples relevant to our culture and surroundings is like: '*Don't go always with what your culture and surrounding is doing.' Do something unique so that it is useful and easy to take care.* Like noodles factory and way to make *tingmo* [a Tibetan steamed bread]. Now you should make more *tingmo* in shorter time. *Do, think, and create something new*."	

Table 4.10 continued

"Because *in our Tibetan society we have things which can be used to engineer and also we need to improve some of our metals*."	
It made us think more easily.	**3**
"This is also a good thing to connect with our culture and surroundings, because things we do usual. *Therefore, we are more aware about them. Which makes us think more easily*."	
"*These connections make us easier to imagine the things better*. Which ultimately lead to proper understanding and memorizing of the course."	
"It created an image that engineering is very simple if you/we use our idea. *So it eased our mind*."	
It helped us to visualize the abstractions in our familiar context.	**3**
"I think it was good because it was practical in our society. *Helped us visualize and realize mechanism hidden there*."	
"*It gave us more insights* of the way of manufacturing *that we take for granted*."	
"In a way, it was a great idea. *Getting to know the things related to engineering in our own community*. And knowing or *actually seeing those things work out very well & at the same time seeing it's benefits* the community's living was great."	
It made me curious and/or interested	**2**
"I found it a very good way of explaining the course, *which made me more curious and interested in the course*. It helped me in understanding the course."	
"Your way of connecting engineering with examples relevant our culture and surroundings is interesting and you always tried to show us relation between them."	
It made me think more on Tibetan culture and tradition.	**2**
"It was nice to give examples related to our culture and *it made me to think more on our culture and tradition*."	
"*Our culture is 'others before self'* and help others if you can, but not harm them even if you are in difficulties. *Likewise, you connected engineering with our culture that how to help other and their need*."	

Table 4.10 continued

It made us see that our people also engineer, but in a different way.	**2**
"It was really nice as we can also realize that *in our country also the people are using lot of engineer methods in daily life*. Even if its rare for them to have the degree *but they have the skill to engineer*."	
"It's beautiful and *we felt happy when we saw those examples of engineering. It actually shows [that] Tibetans, although don't have the tradition of studying engineering, indirectly we (our Tibetans) are engineering*!! So *I felt a little proud* that Tibetans make those things from ancient time so *we were engineers of old time. We have the potential*."	
It helped us to be more attentive because it was a familiar context.	**2**
"*These examples can attract more seriously us. We are really dealing with does things*."	
"It was very creative of you to do that because *we get more active & attention when we heard something which is quite familiar to us*. It gave us more insights of the way of manufacturing what we take for granted."	
It was a different way to teach engineering.	**1**
"I think it's awesome and *it is a different way to teach engineering* by relating the topic to Tibetan culture."	
The connections are good to understand engineering.	**1**
"I think it is very good that, practically, you tried to explain with examples which are related to engineering. *Your connections are absolutely good for us to understand engineering*."	
Engineering can be applicable to our daily life. It is not always to design huge things.	**1**
"From my point of view, it made me realize that *engineering is not always as huge as building aircrafts, railway tracks*, etc. and the knowledge of engineering *can be applied to meet the basic needs of our daily-life* activities!"	
From a small context we can also learn many things.	**1**
"[I] got an idea that *from small things we can learn many things*."	
It is a good method for people who do not have knowledge about engineering.	**1**
"I think that the way you connected engineering with examples is relevant to our culture and surrounding. Through simple examples, *you are trying to guide students who don't have knowledge about engineering. I like your method of guiding and teaching*."	

Table 4.10 continued

Culturally relevant photos made your presentations more interesting.	**1**
"*Beautiful photos with reality connections make your electronic presentation little more interesting*."	

In summary, the students felt that the culturally responsive approach (including the design project) helped them to see that they can make changes in their surroundings. The connections between engineering concepts and their familiar settings were seen as an effective way to easily associate them with something that they have seen before. The reflective questions made them think about their culture and tradition. They appreciated the inspirational and inclusivity component because they saw that I taught that what their people made and make is a form of engineering, but in a different historical or location context. Some students felt that the approach helped them feel curious or interested (because of its familiarity). Others reflected on the fact that even in a small community one can find ways to associate engineering to it. Finally, a student noticed that the approach is good for people without any background in engineering.

According to these data, the students thought that the course approach was respectful of their cultural background, aligned to the intention of the course and the approach of teaching. Interestingly, the theme that had more responses had to do with *change and empowerment* ("it made us see that we can make changes in our community"); therefore, some of them thought that the course did not just have a "culturally responsive" component, but that it also gave them a space and inspiration to make changes in their school by their efforts.

4.7.6 Connection between engineering and Buddhism

In Table 4.11, the shaded rows indicate the general theme and the indented text below each shaded row are the students' quotes associated to the theme. I decided to show the students' quotes in this table (as with Table 4.10) because their responses were more complex and had to do with one of the core components of the course. The italics indicate the part of the quote which I used to define the theme.

Table 4.11 What They Thought about the Connection Between Buddhism and Engineering

It made sense to connect engineering to the six virtues.	**7**
"One must need *good concentration* while we are setting plan and designing as well as one must need *good ethic, otherwise she/he will not succeed due to lack of moralities*."	
"I thought, this method was awesome! Because of this [illegible] there are [illegible] engineers. Who were good and creative, but due to their low thinking about others, there are [illegible] of destruction occurring. *Therefore, six perfections are necessary to be an engineer*."	
"I think Buddhism is beyond religion. Many part of [*Buddhist] scriptures are using our wisdom, logic, observation and thought, so it helps on engineering*. So it is good idea."	
"*Most of the time you had tried to relate things with six perfections (virtues) & interdependence*. Especially it relates with sustainable engineering."	
"*I think it's very reasonable to connect engineering to these six transcend perfections* and other principles of Buddhism. But as per our Buddhist teacher *these disciplines are very high standard that we the common people (full of sins) are not using them at this stage. But we are practicing a little part*."	
"From my point of view, *all are very relevant and are helpful in daily life. I'm trying to practice them as much as I can*."	

Table 4.11 continued

"The way that you connected engineering with Buddhism, I felt it was like: '*Work for others, and help others*, *they will help you back*.' When an engineer solves a problem, then automatically your problem is also solved. It is like: '*Do help others, like an engineer, but not like a bad engineer. They ["bad engineers"] harm society more than other people*.'"	
Their concerns.	**3**
"I think it was enough to connect engineering with Buddhism, but *Buddhism is so wide and we can't explain it and said [in] one period. So, [do] more study and explain deeply or more*."	
"As you mentioned to answer the questions truthfully, I can't say anything about it because while having the course *I did not come to know that much about this connection*."	
"*I don't know whether it [engineering] connects with Buddhism or not*."	
It can be applicable to other cultural groups as well.	**3**
"I think it is very good for the universe as a whole. It may make engineering hard enough, as they [engineers] should think big enough. *However, this would be great for the whole humanity by [illegible] them to improve their life style without much more loss and impact*."	
"It is very great for you to connect engineering with Buddhism. *Whatever you want to achieve will be very useful for the society….Whatever you mentioned about is very necessary for a person to think and act*."	
"*Buddhism is a religion that leads people to non-violence* and toward engineering. It helps to create a better project."	
It can translate into good results in the society.	**3**
"I think it is perfect to explain engineering with above examples, because *it always yields good results for the society. Buddhist ideas must be needed to engineer*."	
"Wonderful skill which is linked Buddhism to the engineering fields is *a good way for engineers to be social changers*, that is mind setting."	
"I think *it would be helpful to think and bring better innovations, and use the things in a more meaningful way*. *If we can connect engineering with Buddhism it will bring a good product*, I think."	
It made us feel included in engineering education.	**2**
"I think it's great and also very innovative to the students who are very interested in engineering fields. *We are Buddhists. We realized that engineering can be done with the help of our own religion (i.e., the six perfections, etc.)*."	
"*It gave us (Tibetan students) more interest and hope to pursue [study] in this field* as it made us think than we can contribute something in this field through our own Buddhist knowledge."	

Table 4.11 continued

The connection is 'hidden' (not conscious) in us.	**2**
"*I think it is a very difficult task to do. Normally these (examples) are hidden in human nature*. Whether one is a foreigner or a Tibetan who is embedded with these values, one is using them in every day experiences indirectly or directly."	
"To us, *we all are not at this level to connect a Western subject with ours*. Yet, I think it is more basic in ourselves like feeling extreme compassion when we see an animal is dying. *The point is we (I) can't directly put our philosophy, but indirectly it is in our nature through that use*."	
Perception that Buddhism goes along with contemporary science.	**2**
"As a Buddhist, I think that you know quite well on Buddhism. So you connected well between engineering and Buddhism. *Science is development of physical world and Buddhism is development of mental. So combining both can achieve greatness*."	
"The way you connected engineering with Buddhism, is really a good idea, because *Buddhism is a religion that can go with modern science. They are the same concept and also it's really connected with our daily life*."	
It is an applied Buddhism.	**1**
"Yes, it is very good and interesting when you connected engineering with Buddhism. Because I think that *thinking and philosophy of Buddhism should be practical in engineering*."	
Felt motivation by seeing a non-Tibetan interested in our religion.	**1**
"*I was motivated by this because a non-Tibetan was taking interest in our religion*. I felt that Buddhism was indeed a special religion and wanted to spread it to more people."	
It was a novel idea.	**1**
"*It was actually the first time I noticed that engineering can be connected with Buddhism [another innovation here*]. I thought it was a new kind of thing and I guess it was very much interrelated/connected. I think we should connect things and make real sense out of it. I really appreciate the idea."	
Because what engineers believe and value is important.	**1**
"I found it good. As *what engineers believe and value is one of the main things*."	
It connected with sustainable engineering.	**1**
"*This is very much connected with Buddhism: That our way of thinking can base sustainable engineering*, fulfill the need of people, and make their life simpler."	

In summary, students mentioned that it made sense to connect the six virtues with engineering teamwork. Some thought that it made sense because of their belief that contemporary science goes along with Buddhism.[60] Some thought that the approach could be applicable to other peoples (not just Tibetans). They thought that the approach could bring positive results to society. In some of their responses, they mentioned that their Tibetan and Buddhist sociocultural backgrounds were included or welcomed in the course. They acknowledged that they are reflecting on the six virtues and engineering from their perspective of layperson Buddhists (not at the level of monastics). Interestingly, one student felt motivated by seeing me (a Westerner) very interested in their religion. Others thought that the course was novel. They appreciated the connection to sustainability, focus on values, approach to explain the design cycle, connection with society, and originality of the course.

Three students shared their concerns. Two students said that they did not understand the connection between Buddhism and engineering. One student acknowledged that Buddhism is very broad, and that I will need to study more to explain better the connections.

The fact that many students believed that it made sense to connect to Buddhism and others did not see the connection is an indication that perhaps some students were resisting the course approach. Others can extrapolate on these findings in the following ways: Although culturally responsive teachers can do everything possible to align a course with the values and missions of a school, there will always be some students who will resist this approach of teaching. The factors can be very complex: generational

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[60] Refer to section 4.5.2.3 for a discussion about why some students see this connection.

differences, impact of what is considered to be “modern” versus “old,” expectations of the teacher and knowledge that will be taught in the course, resistance to authority, and so on. I would suggest teachers to use a different teaching method that does not involve associations with “culture” for those students who resist.

4.7.7 Their recommendations

Table 4.12 Their Recommendations

Way of teaching	
Talk louder.	3
Approach “silent” students individually. We “do not have [the] habit to ask questions and [be] frank.”	2
Include an interpreter (translator).	1
“Better to discuss more while teaching.”	1
“I would delete spoonfeeding[a].”	1
“I would apply the method of Tibetan dialectic [debate] where students think critically and enjoy their study.”	1
Ask the students to write in a notebook what they are learning.	1
Show more examples.	1
Culturally responsive content	
We “feel happy” when you relate or compare engineering with our “customs and traditional methods.” Add more of those examples.	2
The connections with Buddhist philosophy concepts were not clear to us.	1
Emphasize in Buddhist morality because “a top engineer can be destructive without moral values.”	1
For future courses, the teacher should have knowledge in Tibetan Buddhism.	1
Introduce interdependence and then relate it to the world.	1
Engineering content	
More valuable with mathematics and physics.	2
Talk more about the “possible changes we can bring to our old society.”	1
Add more videos relevant to engineering.	1
“Detail explanation on one topic will be more productive[b].”	1
Enrollment and scheduling	
Schedule the course in a vacation time.	1
Increase the number of students who can enroll in your course.	1

Table 4.12 continued

Other	
Provide Internet.	1
Tell students about sources of scholarships.	1

[a] This student's meaning of "spoonfeeding" was unclear to me. My interpretation is that either my way of interacting could have been perceived as "maternalistic" or the student did not like my dull lectures. This student belonged to Team 8, which experienced a lot of difficulty undertaking its design project (see chapter 6, section 6.9 for more information).
[b] I assume that the student is suggesting that I should have focused on one engineering discipline only.

In summary, two students recommended I approach silent students individually, rather than in a group. Two students said that it would have been more valuable if I had added physics and mathematics, a reflection of their need to develop these academic skills to pass university level engineering entrance examinations with high marks (scores). Two students praised that I connected to their ways of living, thus, they encouraged me to add more of those examples. Other suggestions that I would like to point out are the need to have a Tibetan interpreted (translator) in class, to bring more relevant examples that show the real work of engineers (in addition to showing examples that connect to poverty alleviation, as I discussed in section 4.3), to incorporate Tibetan debate, to change the approach of talking about interdependence, and to emphasize in Buddhist morality.

Their recommendations revolve around the reality that teaching subjects to students in a context where both the teacher's and the students' first language is not English can be even more challenging for both. In addition, there will be students who will find effective the connection to their culture, but there will be others who will resist a way of teaching that connects to culture. Furthermore, some students will need a course that helps them to excel in mathematics and physics more than what I offered because of the emphasis of these two subjects in engineering college entrance examinations (such as India's Joint Entrance Examination) and engineering programs.

4.7.8 Overall summary of their feedback

To summarize their course feedback, overall, the students were satisfied with the course. They felt that the course helped them gain insights about how engineers create things by experiencing themselves through the experience of design. The course content and project were aligned to their Buddhist and Tibetan cultural backgrounds, meaning that they were inclusive of their value of altruism and their identities as Tibetans and Buddhists. The sustainability and community service component of the design project and the demonstration of how engineering concepts can be connected to their familiar contexts (e.g., school, ways of living in Tibet, and host country) were inspirational. Their major concerns were that (a) the lectures were dull and that I was soft-spoken, (b) they lacked time to do their projects (because the design project was extra-curricular and competed with their need to study for the other courses), (c) they expected to learn a lot more from me, and (d) they experienced language barriers.

Culturally responsive approaches of teaching and design projects can be implemented in other schools that value the cultural identity of the students and that have the mission to nurture (or strengthen) it; however, teachers should be mindful that there could be students who will resist teaching approaches that connect to culture.

4.8 Summary of chapter 4

This section summarizes the chapter to answer the research question: What are the processes to develop and implement a culturally responsive introductory engineering course? The product of this chapter is a model of development and implementation of the course, represented in Figure 4.5. In addition, section 4.8.1 provides generic recommendations for teachers, helping to answer the second part of the question (i.e., the development of the course).

Figure 4.5 summarizes the most important phases and activities that I passed through to develop and teach the introductory engineering course. I generalized each process to answer the research question in a way that enables teachers to use and contextualize the framework and contextualize it to their particular school.

In Figure 4.5, the arrows show movement and direction. The unidirectional arrow from the start circle points to the "Prepare to teach" phase, which is composed of four bidirectional activities forming iterations, representing the processes that helped me to prepare to teach. These four bidirectional activities were (a) meet with school administrators and teachers, (b) develop curriculum, (c) learn about the school, and (d) learn about the students. I undertook all those activities to prepare myself before teaching.

The lines without arrows represent subcomponents of an activity. For example, I learned five major things about the students as symbolized by the five lines that extend from the "Learn about the students" activity in the left-upper quadrant of the graphic. What I learned about the school is symbolized by two questions connected to the

“Learning about the school” activity. There are the most relevant activities that can inform other teachers, but they are not the only ones.

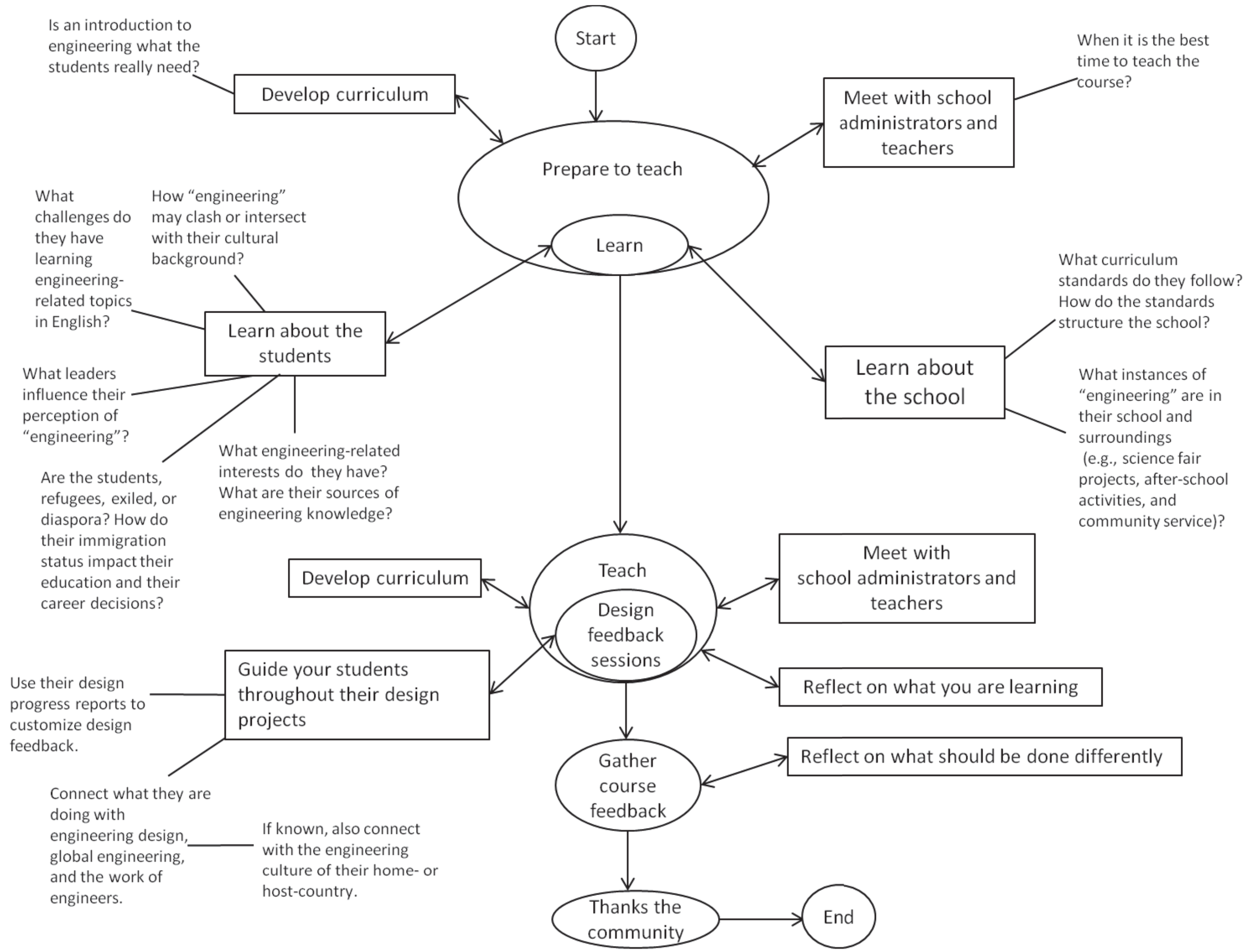

Figure 4.2 Processes to develop and teach an introductory engineering course (generic abstractions)

There are multiple iterations to, from, and within these four major activities of "Prepare to teach." Then we step on the "Teach" phase. The teaching phase has four activities: (a) develop curriculum, (b) reflect on what you are learning, (c) meet with school administrators and teachers, and (d) guide your students in their design projects. These are also in the form of iterations to, from, and within them. The last two phases are "Gather course feedback" and "Thanks the community." The former is a reflective activity and the latter is to give thanks—give thanks because all what you accomplished might not have been possible without the support of the community.

Next, I will provide a general summary of my recommendations described throughout this chapter.

4.8.1 My recommendations and generalizations

Aligned with the literature (Castagno & Brayboy, 2008), preparing an introductory engineering course through a culturally responsive approach took more effort than would preparing presentations with introductory engineering information for a general audience. In a school that follows curriculum standards, it may be challenging to implement a course such as the one I proposed, particularly if the teacher will also supervise students' design projects by the means of feedback sessions.

The course content may change even during and after the intervention, based on student feedback, how students are reacting, and the teacher's praxis (Freire, 1970). The design of feedback sessions, and even the development of design progress report guidelines, may change based on students' previous submissions, the students' particular design projects, your praxis (Freire, 1970), and the teacher's knowledge about the engineers' work in that cultural group, nation, or host country in the case of refugees.

Teachers can use content that connects to (a) students' familiar ways of living in the host country and homeland, (b) multicultural content, (c) engineers working in industry settings (in the host country, homeland, and globalized contexts), and (d) engineering projects to help alleviate poverty or suffering. Second, teachers can implement a design project that is inclusive of the value of altruism that is important in most cultures. Finally, the teacher should first identify the students' priorities before developing and implementing a course in such school contexts to adapt the course to their needs (e.g., the need to pass engineering schools entrance examinations).

If I were to implement this course again for another ethnic group, I would retain the content that (a) associates engineering to a group's ways of living (e.g., sociocultural background), (b) shows the real work of engineers in the country and in global engineering, (c) explicitly shows how engineers are alleviating poverty, and (d) explicitly shows how engineers care for the environment and ecology through their innovations. I would also retain the community service learning activity because many students, Buddhists and non-Buddhists alike, will benefit from it.

If I would taught the course in a Buddhist-influenced school (or to Buddhist students), I would retain the Buddhist framework, but I would adapt it to the school context, students' needs, sociocultural context(s), and their Buddhist tradition. The content that connects with dependent origination should be revised to be more explicit or perhaps should be omitted. It will depend on the advice of school administrators. If the students are not Buddhists, teachers should omit any reference to Buddhism to be respectful of others' religious beliefs and identities.

To summarize the most important points that I learned developing curriculum and teaching through a culturally responsive approach:

- Intention is not enough. We may have the wholehearted intention to do good with what we think are the best teaching methods, but they may fail even if that was not our intention. Therefore, we should try with other teaching approaches when "culturally responsive" approaches do not work.
- One's expectations about others are powerful ideas that mediate the interactions between oneself and others—in my case, between my students and me, and vice versa. These expectations are impossible to avoid, but we can always question our expectations and assumptions in order to care more for our students.
- Some of us in the "West" have expectations about the "poor" in developing nations in the "East" that may not be attuned to the fact that many of those nations have already capable people with technical skills—sometimes more advanced than us.
- Ethnic identity sometimes is stronger than religious identity. Therefore, even when both teachers and students share an identity, the ethnic or national identity may still be a powerful boundary to which one as a teacher needs to work around it and respect.
- CR teaching has more barriers and could be even impossible when the teacher is not part of the cultural and linguistic backgrounds of the students. Students

could resist a CR approach if they have been acculturated or have been influenced by the discourses about modernity, development, and progress often associated with engineering and technology because we will be associating a “modern” subject with a “traditional” content. *However*, if one is in a school that values the cultural identity of its students and has the mission to develop and strengthen that identity, this way of teaching respects and supports those values and missions.

CHAPTER 5. HOW BUDDHISM INFLUENCED TEAMWORK AND ENGINEERING DESIGN

5.1.1 Introduction

This chapter explores a subset of my second research question: How does *Buddhism* influence the students' design experiences and teamwork? The chapter is divided into two major parts: Data from each team's reports and data from interviews of two Tibetan civil engineers who have worked as engineers most of their lives. In section 5.2, I will explain how the students thought that the six virtues of the *Mahāyāna*-Bodhisattva path supported their design process and teamwork. In section 5.3, I explain how the Tibetan engineers thought that Buddhism (again, the focus is in the *Bodhisattva* path) has supported their design and teamwork experience as communication skills needed to overcome their design and teamwork challenges.

I purposely separated Buddhism from Tibetan culture in the analysis of my second research question: not all Tibetans are Buddhists, so I thought that it was a more proper way to analyze my findings. Chapter 6 presents the Tibetan culture part of the study.

In this analysis, when I refer to Buddhism, I am focusing on the core practice of *Mahāyāna* Buddhism that is the *Bodhisattvayāna* or the "Way of the *Bodhisattva*." As explained in Chapter 2, section 2.4, Tibetan Buddhism is a synthesis of *Mahāyāna* and *Vajrayāna* forms of Buddhism. I did not focus on the *Vajrayāna* part in my study because this form of Buddhism is beyond my comprehension. In addition, some of those practices are considered secret; therefore, Buddhist laypersons (Westerners and Tibetans) do not have access to them. Therefore, I focused only on the foundational practices and notions of *Mahāyāna* Buddhism, which I believed could support the communication skills that engineers also need in teamwork (e.g., patience, perseverance, empathy, and so on).

In section 5.2, I looked at each team's engineering design process and teamwork because, during my students' work, I reflected on what is engineering, and I observed how this phenomenon we call "engineering" is multidimensional. It is about investigating a problem, applying physics and mathematics, and designing a solution, but it is also about teamwork. Engineering can be viewed from many different perspectives; from my perspective in this study, the center of engineering design is the team.

In my report guidelines, I asked my students and Tibetan engineers for their thoughts about how the six *pāramitās* (six virtues of *Mahāyāna* Buddhism) helped them in their projects for these reasons: (a) I assumed that they were familiar with this Buddhist practice; (b) I wanted to follow a culturally responsive way of teaching and interacting, and therefore asking them to reflect on these principles was a way to show respect for their Buddhist-influenced values; and (c) I wanted to help the students reflect on the importance of these communication skills in design and teamwork, and in the case of engineers to understand how they thought that these skills were important in their work.

Tibetan laypersons who consider themselves Buddhists view Tibetan Buddhism as part of their ethnic culture (Coleman, 2001). Tibetan laypersons usually focus on seeking the inspiration (often translated as "blessings") and advice of *Lamas*, performing pilgrimages, fostering actions that will develop *Bodhicitta* (altruistic mind), praying, performing practices of purification, observing auspicious days, performing special rituals on Tibetan holidays (such as *Losar*, *Saka Dawa*, *Zamling Chisang*, and the birthday of His Holiness The Dalai Lama), and being mindful of their *karma* (Sanskrit word for "actions") because it is believed that one's *karma* (actions) not only take effect on this realm, but also will determine the future rebirth (Mitchell, 2008). The Western convert views Tibetan Buddhism as a "religion" or "spirituality" to which you need to *convert,* and it could be impacted by Western regionalisms (Wilson, 2012) and each practitioners' sociocultural backgrounds (Gutiérrez Baldoquín, 2004). Therefore, the phenomenon we call Buddhism, as any other culture or belief system, was constructed differently in the West because of the Western particularities existing where Buddhism took root: Individual and collective politics, historical processes, ideologies, previous cultures, national values, and previous religions that were already in the "soil" of that region.

When Tibetan Buddhism arrived in the West between the late nineteenth and early twentieth centuries (López, 1998), the reinterpretation of Buddhist practices in a Western context (and to fulfill the demands of the Western world) reconstructed Tibetan Buddhism *for* the West. This constant movement of the Tibetan Buddhism phenomenon from East to West and West to East reconstructs its practices and its understanding. Even more, both parties (Tibetans and Westerners) learn from each other and influence each other's versions of Orientalism (Said, 1994) and Occidentalism (Carrier, 1992).

Occidentalism (Carrier, 1992) is the collection of preconceptions, assumptions, imaginations, and expectations about the "West" and "Westerners" constructed by an individual or a group of people. Similarly, Said (1994) described *Orientalism* as

> Cultural, material, and intellectual relations between Europe and the Orient have gone through innumerable phases, even though the line between East and West has made a certain constant impression upon Europe. Yet in general it was the West that moved upon the East, not vice versa. *Orientalism* is the generic term that I have been employing to describe the Western approach to the Orient; Orientalism is the discipline by which the Orient was (and is) approached systematically, as a topic of learning, discovery, and practice [emphasis in original]. (p. 73)

Countries in the Asian continent and the Middle East are regarded as the "Orient" (Hill, 2009), although some include the African continent as well (Singh, 2004).

The discussion about Orientalism and Occidentalism serves as a preamble to the argument that I will now make about my experience designing and implementing a culturally responsive course. In my study, I made connections between Tibetan Buddhist philosophy concepts and engineering in order to be respectful of the people's culture. I wanted to align my methods with culturally responsive pedagogical guidelines outlined by others (Gay, 2000; Ladson-Billings, 1995; Phuntsog, 1998, 1999). However, I found that in this case (a Western Buddhist convert teaching in a Tibetan laypersons' society in exile), the teacher should be mindful not only of his or her interpretations of Tibetan culture and Tibetan Buddhism but also of Tibetan students' interpretations of Buddhist concepts. For example, I found that concepts such as *karma* have been internalized differently in Tibetan laypersons. For some, it can have the negative connotation of "fate" or "destiny." Connections between "dependent origination" and the engineering design cycle might resonate with monastics, but *some* laypersons could face difficulty in understanding engineering concepts by associating them with Buddhist philosophical concepts. Therefore, teachers should be mindful of this reality and adapt their examples to what the student can understand. In the next section, I will discuss my findings that led me to this understanding.

5.2 Students' reflections

In this section, I analyze data from each team's reports and final project presentation. I place focus on the responses to the following questions:[61]

- How do you think that Tibetan dialectics [debate] is influencing your (1) team work and (2) design process?
- How do you think that the six virtues (generosity, discipline,[62] patience, perseverance, concentration, and wisdom)[63] are influencing your (1) team work and (2) design process?

[61] The questions were written slightly different in Appendixes A, B, and C. The ones that I mentioned in this page came from Appendix C.
[62] Also refers to Buddhist morality or "ethics." The terms that I used in my thesis were Buddhist morality or ethics instead of discipline.
[63] The original sentence had words written in Tibetan. I translated them to English.

- Did you think about the Buddhist idea of "emptiness" (nothing exists independently of other causes and conditions) when you tried to understand the causes and conditions of your design problem? Please explain why "yes" or "no."[64]
- How do you think that your Tibetan beliefs are influencing (1) team work and (2) design process? (Example: *karma*, etc.)

For data triangulation, I refer to interview transcripts and my fieldnotes. Before each team section, I provide the team's demographics.

5.2.1 Team 1: The design of a garbage incinerator

The four team members were male, in class 10+1, ranged in age from 19 to 22 years (inclusive), and were born in Tibet. Their design was a model of a garbage incinerator. In their school, they need to burn garbage every week and they thought about improving the garbage incinerator structure (e.g., designing another one that can have a way to trap ashes).

Among their responses in one of the reports, this team wrote that they did not believe that their beliefs were influencing their design. They explained:

> Our Tibetan beliefs do not influence our teamwork and design process. Because for a good output we should join hand to hand and work for it. Then the result will be colorful.

[64] This question is more specific because the notion of emptiness is a key construct in Buddhism that have to do with "interdependence" and "dependent origination."

This statement made me think of four issues. First, they might be influenced by the Western-positivist view that permeates science in modern education (Cobern, 1998). Scientific positivism is the view that science is an objective truth, and therefore technology is objective as well and is not tainted by the subjectivism of culture, politics, or economic power. Second, because they were born and raised in Tibet, I should consider how much the Chinese discourse of "quality" or *suzhi* (Murphy, 2004) in the Chinese modernist narratives in education has influenced them. These ideological discourses are targeted to promote a "quality" of behavior and character in peasants (including some Tibetans). *Suzhi* emerged in the 1980s, when China began its newest modernization period and embraced the globalized economy (Murphy, 2004). Murphy (2004) traced the history of this term back to Confucian teachings, Social Darwinism, Mao Zedong's pronouncements, and Marxist theory. Murphy (2004) explained how *suzhi* discourse is connected to the Chinese modernization discourse:

> *Suzhi* derives part of its ideological potency through its reinforcement of related systems of valuation already embedded within Chinese development discourse, such as town versus country, developed versus backward, prosperous versus poor, civilized versus barbarian, and to have culture (*you wenhua*) versus to be without culture (*mei wenhua*). So although concerns about *suzhi* pertain to the entire population, groups in lower valued situations are seen to need special remedial attention. Such anxiety about the backwardness of particular groups is not unique to China. Many scholars document how in a variety of social and historical contexts, nation-states perceive a problem in the "backwardness" of certain

> groups, in this case rural people, and designate a pivotal role for schools in "civilizing" them. (p. 3)

Third, the students might think that some of their cultural beliefs and values are opposed to "technological progress." This makes sense if you consider the following scenario: If people "cling" to the view of *karma* and rebirth, then why would they start the construction of a building, if they will inevitably kill animals in the process? Therefore, some Buddhist beliefs appear to be in opposition to the effects of some actions that engineers need to do. On the other hand, traditional Tibetan Buddhists have rituals that attempt to counteract the negative *karma* of killing animals on the site, especially before the construction (Schrempf, 1999).

Fourth, the fact that the students are Tibetans does not mean that they agree with all of their cultural beliefs. As a Tibetan school administrator explained about Tibetan students' view of Buddhist beliefs:

> It doesn't mean that Tibetan students are all Buddhists with a good concept and understanding, no. Because, when we lost our country, in India there was a frustration period. Many even though after all whether they are Buddhists or whatever…. They like us, they have faced conflicts, tensions between having no parents and as refugees; the alienation that they are refugees and have suffered.

Because not all layperson Tibetan students will have the same interpretation and experience of Buddhist beliefs and practices, a risk arises when Western teachers make connections between Buddhism and engineering (or any other subject), as I did. As Coleman (2001) argued:

> As we have seen, in most forms of traditional Buddhism there is a sharp distinction between the lay people and the monks, nuns, and priests. At least in theory, the members of those elite groups devote their lives to the quest for liberation; sometimes through the kind of meditation the Buddha recommended for his followers, sometimes through strict moral discipline, sometimes through academic studies, sometimes through the single-minded performance of elaborate rituals. For the vast majority of traditional Buddhists, however, the quest for liberation takes a backseat to the demands of everyday life. The most those average Buddhists can hope for is to accumulate merit by good works or through the grace of a powerful Buddha or bodhisattva and someday win a better rebirth either in a paradise or in a life that offers them the chance to devote themselves to the *Dharma* (truth) and win enlightenment. (p. 13)

Understanding these differences between their interpretation and our interpretation of Tibetan Buddhism (and Tibetan culture), Western teachers must be mindful of not projecting onto their students their expectations of what they think Tibetans are, believe, and do. This phenomena of Westerners projecting onto Tibetan culture an idealized view of Tibetans, based on Orientalist (Said, 1994) presumptions, is what Anand (2007) has called in postcolonial studies “exotica Tibet.”

As with all groups, I asked Team 1 members questions aimed to helping them reflect on the idea that engineering design is an interdependent activity (many factors contributing to a final goal), because the concept of emptiness often is interchanged with dependent origination and interdependence (López, 2002). However, the students acknowledged that the concept of *emptiness* is too advanced for them to grasp. This was understandable, because in traditional Tibetan society, the study of emptiness has been attributed to monastic education (López, 2002; Mitchell, 2008) and the experience is perceived to be too difficult or impossible to attain (and I, in my own practice, have not achieved to understand this myself). Nevertheless, they were able to talk about the interdependence of teamwork, which was the aim of the reflection:

> Since we all work as a team, we are interdependent. When we collected the material, each person collected one material. In this way, our project design (or model) becomes successful. The project becomes dependent on our group members. If there is a lack of material, we can't complete it properly.

They thought that the success of their project was dependent on the team members. They saw teamwork as interdependent actions among team members. Their explanation made me reflect on the different meaning of "dependence." For example, in Western society, dependence on others could be seen as detrimental for society, especially in capitalist economies (Scott, 1994; Weber, 2013). In the case of Buddhists, as I understand it, individuals should work together to achieve their goals dependent on the Buddha, Dharma (Buddha's teachings), and Sangha (community of Buddhist monastics).

They acknowledged that they do not have much knowledge on Tibetan debate, and that they tried to apply it through their own understanding as laypersons. They thought that patience and discipline[65] were important to achieving their team goals. When asked about other Tibetan values that might be influencing their work, they reflected on

[65] Discipline is also associated to Buddhist morality and perseverance.

the concept of treating others with equanimity:[66] "Especially treating everyone around us equally when we work and discuss about a topic."

Regarding the concept of *karma*, they explained that when they burn garbage they might kill living beings (e.g., insects):[67] "When we burn the garbage, there are thousands of living beings that lost their life, which causes ecology imbalance and make other living beings lose their habitat." Generosity was seen as the helping hands of others who supported their project. Ethics (or Buddhist morality) was interchanged with the notion of self-discipline. Wisdom was interchanged with knowledge, which belongs to the level of "relative wisdom" rather than "absolute wisdom" (Mitchell, 2008); meaning that they acknowledged that the wisdom they referred to is at the mundane level. They did not reflect on how the virtue of concentration was helping in design or teamwork, but they said that, *in general*, the six virtues were helping them in "creative thinking."

In summary, they reflected on the six virtues: generosity, ethics, patience, concentration (in a general way), perseverance (implicitly), and wisdom. They reflected on concepts like interdependence, *karma*, and equanimity. They acknowledged that they do not have much knowledge on Tibetan debate and that the little that they applied it was from their own understanding as laypersons.

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[66] Equanimity is one of the "four immeasurables," being joy, compassion, and love the other three.
[67] The killing of living beings, although sometimes inevitable in the case of meat consumption, is considered a "negative" form of *karma*. This issue is associated with Buddhist morality.

5.2.2 Team 2: The design of a load carrier

Four members of this team were males and one was female. They were in class 10+2, their ages ranged from 18 to 20 years (inclusive), and they were all born in Tibet. They identified the problem of children moving heavy sacks of vegetables from the canteen to their residences. To address this problem, they designed a load carrier inspired by V. Panchal (Singh, 2011), a design that they found on the Internet.

This group reflected on the importance of generosity ("others before self") to develop empathy. They also reflected on *karma* and rebirth:

> We believe that every organism in the universe has been once our own parents (mother) so we should have to let others before self. Also the law of nature [*karma*] says that if we do bad to others we will be hurt indirectly or directly. As per team work, Tibetan beliefs helped us. For example, we considered ourselves less important than others and, despite feeling shy, we sought help from the Vocational Centre with a lot of respect and words of thanks, so they helped us to show the right path. Also when sometimes a conflict occurred in the team, we forgot it after some time, as we know through Buddhism that suffering is a part and parcel of life.

"Others before self" is connected with the virtue generosity. It is the motto of the TCV school system. It is also a central value of *Mahāyāna* Buddhism (Shantideva, 1979). When they wrote "law of nature," the students referred to *karma*. These are not "scientific laws," of course, but they used the term to state the importance of this belief that regulated the interactions between themselves and others throughout their design process and teamwork. The belief in *karma* is central in Buddhist morality (ethics) and the belief in rebirth. When they wrote “when sometimes a conflict occurred in the team, we forgot it after some time,” they were reflecting on patience.

They considered themselves “less important than others.” In Tibetan Buddhism, there is the belief that an “antidote” of arrogance is to view oneself as lower than the other person. Dhargyey (2003) explains that the cultural view is that when one sees oneself lower than the other, one decreases arrogance and one can live “in harmony with all beings” (p. 107). Under a Western lens, we might consider such thinking as a sign of low self-esteem (which could be true), but under in Buddhist culture it is encouraged as part of their norms to avoid arrogance. At the end of the quote, the students reflected resilience because of their beliefs. In this view, dissatisfaction (*samsara*) is a part of life that everyone must face sooner or later. In fact, other scholars have noted that Tibetan Buddhist practitioners’ beliefs can support feelings of resilience[68] because of the awareness of impermanence and interdependence (O’Connor, Berry, Striver, & Rangan, 2012). Therefore, their awareness of the reality that we all experience dissatisfaction in one way or another has been linked to resilience, which, in the case of my students, impacted their design and teamwork experience.

They acknowledged that their class (10+2 or 12th grade) did not learn Tibetan debate in middle school, but they thought that Tibetan debate could have been helpful in examining the problem and logical reasoning. When they reflected on the six virtues, they provided as an example of generosity that they shared snacks with each other. Ethics (Buddhist morality) was implicit when they interacted with the teachers and

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[68] When combined, the virtues of perseverance and patience could foster resilience.

administrators of the Vocational Training Center (VTC).[69] They required patience when they needed to resolve conflicts (e.g., when their ideas clashed). Perseverance was important in overcoming daily design problems and in doing good deeds. Concentration was associated with the tasks of measuring, cutting, and assembling. When they reflected on interdependence, they acknowledged that in teamwork "every individual's contribution towards our work is important…." Finally, they reflected on emptiness, connected to impermanence, in the following way:

> When we really worked hard for a thing, and then it gets spoiled or broken (useless), then we don't feel much depressed (although we feel a little) because we think everything is emptiness. We can't bring anything with us when we die so what is the use of worrying too much.

In this quote, they expressed that their laypersons understanding of emptiness helped them to counteract their feelings of disappointment when they did not meet their expectations. Their final sentence mirrored Shantideva's (1979) thought:

> Why be unhappy about something
> If it can be remedied?
> And what is the use of being unhappy about
> Something if it cannot be remedied? (p. 54)

In summary, they explicitly connected their teamwork with generosity, patience, perseverance, and concentration. Ethics and wisdom were implicit when they talked

[69] As mentioned in chapter 4, section 4.3.1, some students went to the Tibetan Vocational Training Center (VTC), which is within walking distance of the school, because it had facilities to implement their design (e.g., a carpentry workshop).

about their team relationship. In addition, they reflected on concepts like *karma*, impermanence, and the belief in rebirth.

5.2.3 Team 3: The design of a portable cart

All four team members were males, in class 10+1, and younger than 18 years. Two team members were born in India and two in Tibet. They identified the problem of transporting cut grasses within the school limits. Since the design was going to be used for children, they thought about a portable lightweight cart.

When they investigated the causes of the problem that they identified, they wrote:

> It may be due to law of *karma* or his mishandling. In Tibetan Buddhism, everything is due to cause and effect. Due to his actions in earlier generation, he faced the reaction in today's life.

In the quote above, they examined how Buddhist morality (ethics) connected with *karma* and rebirth was relevant in their project problem context. The quote made me think that teachers should be careful of integrating concepts such as *karma* that may have a variety of interpretations. For example, I define *karma* as "your previous actions," no matter if they are beneficial or not. In this case, the student was referring to "negative actions." I advise teachers to be mindful of the possible differences between one's understanding of a cultural construct and the students' understanding of it.

The team emphasized that ethics helped them in teamwork:

> When we were discussing our model, we mainly based the discussion on our ethics by listening and understanding carefully to what our group-mate had to say and pointing out some mistakes from their point through mutual understanding.

They interpreted ethics (Buddhist morality) as "listening and understanding" to account for other's views and to point out mistakes of others. Research has found that the skills of an effective project manager include empathy and listening (among other traits) (Posner, 1987). Therefore, this team exhibited an intuitive understanding of project management.

The team quoted Nāgārjuna, a Buddhist philosopher who founded the *Mādhyamika* (middle way) school of philosophy of *Mahāyāna* Buddhism, to support their view on the importance of ethics (morality):

> Earth is [the] basic need to [everything that] exists. [To] both living and non-living. Likewise earth, ethic is basis of all knowledge.

In this context, "earth" is one of the five elements of pre-scientific Buddhism (earth, wind, fire, water, and vacuum or space) (Dalai Lama, 1992). "Knowledge" can mean both relative and absolute wisdom; therefore, engineering knowledge is applicable in the quote as well. As I interpret it, these students appropriated Nāgārjuna's quote to make meaning of their teamwork experience and justify on the importance of ethical conduct in teamwork. The simile thus can be interpreted as follows: The earth element is the basis of everything that exists. Like earth, ethics (Buddhist morality) is the basis of good teamwork.

They reflected on the connection of concentration by explaining that they "fully concentrated on designing the model by thinking in an analytical way about it and gathering knowledge from the library." As did other teams, Team 3 acknowledged that emptiness is a notion beyond their comprehension (which is true even for me). However, they reflected on the interdependence of teamwork:

> It's very clear, our project will not happen without the helping hands of our friends and mentor (Marisol) who passionately shared her view and review on our reports. It [emptiness] shows that nothing can be accomplished independently. [The] fruit of success depends upon numerous causes and conditions such as our friends' help in our project.

The success of their project depended upon others. In their case, they mentioned their friends and me (the teacher). They also referenced an English proverb:

> As the saying goes "where there is a will, there is a way." Likewise, with help of strong willingness, we found tires of broken bicycles, and through these difficulties we came to realize our will power.

Even though the students are ethnic Tibetans, they live in northern India, and participate in India's education system, which was been influenced by the British education model. Therefore, using an English proverb is not at all unusual.

As with other teams, Team 4 acknowledged that they had little knowledge of Tibetan debate. Traditionally, this method of teaching and learning is part of Buddhist monastic education (Perdue, 1992). Until recently, it was not associated to contemporary education for laypersons. Although I was aware of this, I asked each team how Tibetan debate was helping them in their design and teamwork because I learned that TCV Selakui was starting to include debate classes at the middle school level. From their responses and my observations, only a few students of my class have practiced Tibetan debate methods, perhaps because until recently it was not given priority in the contemporary education curriculum of Tibetan Buddhist laypersons. I also have to acknowledge that due to my language limitations I cannot offer more insights into the possible influences of Tibetan debate in their design and teamwork.

5.2.3.1 Minimalizing team conflicts

The team wrote about the importance of ethics (Buddhist morality):

> When we were discussing our model, we mainly based the discussion on our ethics by listening and understanding carefully to what our team-mate had to say and point out some mistake from their point through mutual understanding.

During a feedback session with the team members, I asked what they meant by "mistakes." One team member replied, "[They were] wrong suggestions." When asked to elaborate, he said, "It was not exactly related to our project. That we needed some…" Still not clear of his meaning, I asked additional questions. Finally he said, "[They were] not disagreements. When we were discussing about our team project, some points which were not related about our project [came to the discussion]."[70] It seems to me that the team members had attempted to minimalize conflicts that could cause the team to be seen as "disharmonious." This attempt could stem from a combination of (a) the influence of Tibetan Buddhist beliefs in their culture and (b) the pressure to represent well the team and cultural group in front of a Westerner.

[70] It also can be interpreted as applying patience to overcome their tense teamwork experience.

In Buddhism, certain emotions are believed to be "afflictive" or "destructive" if not transformed into nonviolent actions. Some "afflictive emotions" (Tib. *nyon mongs*) are jealousy, greed, and hatred. I interpret the attempt to minimalize their conflicts as the reflection of the Buddhist belief that "divisive speech" and afflictive emotions such as "anger" should not be "cultivated" through actions that can strengthen them more. However, from a different perspective, I can also argue that the students might have been subject to school pressure to show their best, and therefore, minimalized their team's conflicts, especially in front of me—a Westerner. Such actions can even be a reflection of their refugee condition in India. Culturally responsive teachers should be aware that possible sensitive immigration or refugee status of some students may regulate their behavior.

In summary, Team 3 explicitly connected its work with Buddhist morality and concentration. Wisdom was implicit when they quoted Nāgārjuna. Generosity, perseverance, and patience were implicit when they talked about their team relationship. They also reflected on concepts such as interdependence, *karma*, and rebirth. I interpret that the team members minimalized their team conflicts as a result of their Buddhist beliefs and possibly in response to pressure to represent well their team and cultural group in front of a Western teacher.

5.2.4 Team 4: The design of a dog catcher

Two members of this team were male and two were female. The females were ages 16 and 17 years. The males were ages 19 and 21 years old. All of them were in class

10+1. The females were born in India and the males in Tibet. They designed an artifact to catch dogs—essentially, an iron pole with a cord tied to it.

They acknowledged that they were not proficient in Tibetan debate. However, they reflected on how group discussions helped them to negotiate design ideas:

> [H]onestly speaking we all are not that good in dialectics [debate]. Still, at some point of group discussions, we argued and then one pointed out the mistake [of another]. We negotiated things and came to a point. In a way, group discussions are helping us to think out of the box. You know, like critical thinking.

They reported that group discussions involved arguing and then negotiating ideas to reach agreements. They also reported that discussions supported critical thinking. I did not ask them to define "critical thinking." Even in the West, the concept is vaguely defined (Vandermensbrugghe, 2004), and I made the mistake of not defining it clearly in my course. Vandermensbrugghe (2004) explains that critical thinking in Anglo-Saxon education could mean one of two definitions: "The ability to develop a capacity to reason logically and cohesively" (p. 419) and "The ability to question and challenge existing knowledge and the social order" (p. 419). The latter view implies the use of "reason to examine historical and social realities to uncover hidden forms of domination and exploitation" (p. 419). It seems to me that the definition of critical thinking that most closely resembles the process of Tibetan debate and logic is Vandermensbrugghe's first definition, that is, "[t]he ability to develop a capacity to reason logically and cohesively" (p. 419).

Team 4 members thought that moving stray dogs to a safer place was an application of ethics (Buddhist morality). They mentioned that patience was needed to achieve their goals. Regarding perseverance, they shared this thought: "[G]iving up is permanent but learning from not giving up is another thing." I interpreted what they said as follows: Giving up and learning to not give up is two different things. In order to overcome their teamwork difficulties, they exerted perseverance to continue on with their project. Concentration was seen as being required to achieve a goal. Lastly, they acknowledged that wisdom, in the form of relative knowledge, helped their design process.

The team reflected on emptiness in the form of interdependence:

> From our Buddhist point of view, we say that everyone in this universe is dependent on each other. So in our case, even though we depend on dogs to guard our house, *school campus is not a home (it's just our group point of view),* so we must put the dogs in a safer place [emphasis added].

The team members did not consider TCV to be a home, and even though the students depend upon other beings, those dogs in particular should be in a "safer place," although they did not define "safe place." I also discovered that some of my older interviewees had a different view about TCV (i.e., they considered it a home, especially those who were orphans). I believe there could be generational differences in the construction of "home" among Tibetans in exile who attend TCV schools: some consider the TCV system as a "home" and others do not. Other scholars have also noted generational differences in the construction of "home" among Tibetans in exile, in addition to a concern on feeling "homeless" (Bentz, 2012; Choephel, 2011; Falcone & Wangchuk, 2008; Misra, 2003; Swank, 2011).

In a sense, these students (as well as others) are trying to claim their own voice: They, as Tibetans, share collective beliefs and expectations, but they do not necessarily express their *individual* views all the time. In the following paragraph, in which they explained whether the belief of *karma* influenced their design process, I emphasize in italics the tension between the "we, Tibetans" and the "we, individuals:"

> Well, *we Tibetans believe in karma* (cyclic life). I think catching the dog is not actually a good deed, but *from our point of view* we are just helping them putting them in a safer place, so, *we believe, we Tibetans*, in interdependence and not to harm others, so in a way *we are trying to implement it to our best* [emphasis added].

The statement "we are trying to implement it to our best" is a reflection of the reality that, in their traditional Tibetan society, laypersons do not have the education and knowledge of monastics; therefore, they are literally practicing their best knowledge and applying the teachings to their own realities.

In summary, the group reflected on all six virtues except for generosity. I did not find an instance of it in their data; however, I the fact that they were trying to move the dogs to a "safer place" is a form of generosity (humane treatment of dogs). They also reflected on other concepts such as *karma* and interdependence. They expressed their individual views, and they stated that their views are not necessarily those of all Tibetans.

5.2.5 Team 5: The design of a mechanism to ring the school bell

This team consisted of five male students. Three of them were age 16 years. The other two members were age 21 and 22 years. They were all in class 10+1. Four were born in Tibet and one in India. They thought about improving the sound of their school bell. They redesigned the structure to which the bell was attached. They thought about designing a mechanical device moved by hands to ring the bell; rather than using a special hammer.

They thought that exchanging themselves for others[71] helped them to foster understanding: "Yes, Tibetan values and beliefs help us in teamwork as there is understanding and thought of other before self in every member of our team." As mentioned in section 5.2.2, "others before self" is the school's motto, but it is also a value in *Mahāyāna* Buddhism. When asked how the practice of the six virtues helped them, they connected with perseverance: "In order to achieve our project we struggled, never gave up, even when we thought it was time consuming, hard, and very difficult to do, like those metal cutting." In other response, they talked about "cause and effect" or *karma* in relationship to the effort placed in their project: "The more we make effort to our project the good result will be ours. This is based on cause and effect."

They acknowledged that patience, wisdom, and perseverance were important to pass through their design process. In the following quotes, they reflected on emptiness in the form of interdependence:

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[71] This relates to the virtue generosity. It is equivalent to the English idiom "to put oneself in someone else's shoes."

> The view of emptiness, dependent origination and interdependence are the significant philosophy of Buddhism. They are very profound. At large, we can't connect those big and meaningful ideas like emptiness, but we thought that everything is interdependent and our model was possible because everyone took part of the design process.

One of the members of Team 5 was actively learning Tibetan debate, a Tibetan cultural way of knowing and reasoning[72] that was not formally taught in middle school for the students who attended my course. It is my understanding that the student joined a debate club at school because of his personal interest. When asked about how Tibetan debate was helping them, the team said:

> Tibetan dialectics [debate] really influence in our teamwork and in the design process. We overcame a lot of questions and doubt about the project. In the process every individual start to give new ideas and information, then we discuss and make sure the design.

From their Buddhist laypersons' understanding, they explained "Tibetan debate" as a process that helped them to overcome "questions and doubt" in their project (presumably in the investigation of the problem). In addition, they explained "Tibetan debate" as a discussion aid to share ideas and information. If schools for Tibetan Buddhist laypersons implement Tibetan debate classes for all, more research is needed to determine the effect of this way of knowing and reasoning in learning STEM-related topics.

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[72] For more information about Tibetan debate, please, refer to section 4.5.1.

They acknowledged that they are reflecting on how the virtues are helping them in teamwork *through their laypersons' perspective* when they said "we can't connect those big and meaningful ideas like emptiness, but we thought that everything is interdependent…." Since those concepts are very profound for their laypersons' knowledge and experience, they connected it through interdependence by saying that a design solution was accomplished because they all worked together as a team.

5.2.5.1 <u>Minimalizing team difficulties</u>

In section 5.2.3.1, "Minimalizing Team Conflicts" I argued that Team 3 used words to minimalize possible team conflicts, thus, attempting to reduce their importance. I found that Team 5 showed a similar pattern, but in Team 3 case, its members were minimalizing team difficulties in order to focus on how they were able to successfully overcome them.

Team 5 members wrote this statement in one of their reports (I emphasize keywords in italics). They talk about how the problem that they will try to solve is related to society: "…because of that [problem], some [conflicts] take place between staffs and student *(but very rare)*." They acknowledged the conflicts, but at the same time minimalized them by labeling them as "very rare." They wrote in another report: "*[W]e didn't face much difficulty, but we had few*" and then listed their difficulties: (a) "To find an appropriate metal," (b) "To get those materials, we revolved around the school campus," (c) "[We] needed lots of manual force," and (d) "[We needed to] adjust measurements." Although they said that they didn't face many difficulties, the difficulties that they listed were certainly significant to teamwork.

I believe that they minimalized their difficulties because they shifted their focus to a more positive story: They had those difficulties, but they were able to overcome them with perseverance. Because they were successful in overcoming them, they minimalized them to focus attention on the positive side of the story: They did not give up, they persevered. In addition, possibly, as with Team 3, they felt cultural and group pressure to show me (a Western teacher) their best side.

In summary, Team 5 explicitly reflected on the virtues generosity, perseverance, patience, and wisdom. Concentration and ethics (Buddhist morality) were not explicitly connected; however, I believe that they were implicit when they tried to minimalize their teamwork difficulties to shift their story toward a more positive ending: They had to practice concentration and discipline to achieve their mutual goals.

5.2.6 Team 6: The design of a hydropower reading light

Three males and one female were in this team. Their ages ranged from 16 to 20 years. The males were born in India, and the female was born in Tibet. They were in class 10+1. They designed a model of a system that powers up a reading light. The reading light was connected to a small power generator.

This team discussed the role of patience:

> Patience helped us when others (like those who laughed at our idea and our solutions) tried to influence us in many ways. Patience helped us to rethink what was thought before and what was planned in our agenda.

To interpret this statement, they believed that patience was necessary when they felt that others (presumably schoolmates) did not take their ideas seriously. They also expressed a sense of confidence: they laughed at us, but we were confident that our idea was valid. They also thought that patience helped them to redesign and strategize.

They thought that their teamwork required discipline, concentration, and wisdom:

> [C]oncentration and wisdom are the most important ones as they create a medium to get ideas or knowledge about how to design.

> [W]e needed to solve the problem without breaking the law of discipline of society.

Their emphasis on the need to solve the problem "without breaking the law of discipline of society" was likely related to the belief that the foundation of concentration and wisdom is morality, as explained by the Dalai Lama (2005):

> The practice of morality—guarding your three doors of body, speech, and mind from indulging in unwholesome activities—equips you with mindfulness and conscientiousness. These two faculties help you avoid gross forms of negative physical and verbal actions, deeds that are destructive for both oneself and others. Therefore, morality is the foundation of the Buddhist path. (p. 19)

In Buddhism, mindfulness is seen as a precursor to concentration. Practicing Buddhist morality supports mindfulness (and therefore concentration), because one needs awareness of one's actions. Therefore, it is understandable why the students wanted to account for the code of discipline in their society while solving the problem.

The team reflected on *karma* in the following way:

> It is our belief in *karma* to be in a group and having a teamwork together to make a wonderful designed model of a hydropower. Also, our belief of past and next life, because of having an experience in past life we can easily make a design and in the teamwork also. After having this opportunity to have a teamwork within us will definitely make a difference in our next life because of experience.

The quote above talks about their belief that previous actions can determine the present course of a phenomena (in this case being together in a team) and that their present actions can also determine the next life circumstances. These beliefs are connected with Buddhist morality, since they believe that "positive" actions result in "positive" consequences and possibly a better rebirth.

They reflected on the interdependence of teamwork:

> For both teamwork and design process, the ideas of emptiness as well as interdependence are influential because only one member cannot make a well design or cannot have successful results without the helping hands of other members.

While they did not explicitly connect with generosity and perseverance, I believe that they did so implicitly in the quote above when they stated that they needed the "helping hands of other members" to come up with a design. They reflected on the fact that teamwork, like any other phenomena in the world, is empty of inherent existence: It is composed by team members, interactions among them, each one's interpretation of the reality that they are perceiving, among other aspects.

In summary, Team 6 members directly mentioned 4 virtues as being supportive in their teamwork: ethics (Buddhist morality), patience, concentration, and wisdom. I believe that generosity and perseverance were implicit in the way that they talked about the interdependence of teamwork because team members without generosity and perseverance cannot achieve their mutual goals. They reflected on *karma* and rebirth as well. They expressed confidence (self-efficacy) that their design ideas were valid, even when they observed that others did not take their ideas seriously.

5.2.7 Team 7: The design of a rat trap

The Team 7 members were females. Two were age 19 years and one age 17 years. They were in class 10+1. Two were born in Tibet and one in India. They identified problems such as rats and spiders at their hostel and snakes at the school. Because of safety concerns that I had, I asked them to choose between the rat or spider problems. They chose the rat problem and they reused "waste" materials found at the school to design a unique rat trap (see section 6.8 for more information and images).

They explained that the six virtues are characteristics that they need in daily life, and thus also in their teamwork:

> These are required personalities [characteristics] that we need in our daily life. In teamwork, individuals must work hard, control their emotions against delusion and engross in creating innovation.

The emotions that they referred to are those considered to be "afflictive" in Tibetan Buddhism, such as hatred and greediness. They also reflected on *karma* or the "law of cause and effect:"

> Law of cause and effect is a prominent view in Buddhism. It relates with our problem, as garbage corner is the source of rats breeding and as rats multiply.

They reflected on the issue of rats' proliferation through linear logic: Unattended garbage attracts rats, they multiply, and then these rats harm students. Implicitly, they talked about interdependence and dependent origination here, because the problem arise from interrelated factors.

In general, they acknowledged that the six virtues can be used in daily life, including in design. Specifically, they mentioned that the virtues helped them to work hard,[73] control emotions,[74] and innovate.[75] Implicitly, they talked about interdependence when they were describing why the problem arises. They used a linear logic similar to dependent origination when they explained the causes and conditions of the proliferation of rats at their hostel.

To close this section, I argue that one of the reasons why these female students were not able to reflect more to Buddhism is that, in their traditional society, Buddhist-related discussions have more authority when they are discussed an taught by qualified male Buddhist monks; therefore, the fact that I was asking them to reflect on "how Buddhism was supporting their design and teamwork" might not have made sense in their internalization of proper gender norms with regard of who discusses Buddhism and how

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[73] "[W]ork hard" implies practicing perseverance.
[74] "[C]ontrol emotions" implies practicing patience.
[75] It seems to me that the six virtues can also be supportive of innovation because one is focused to fulfill others' need rather than one's needs.

to make sense of Buddhism in their daily lives. In a sense, *I asked them to do a reflection without empowering them first* to see that they can also attempt to make sense of Buddhist principles in their lives, no matter of their gender identity.

In the field, a female teacher at the school said to me that the traditional view is that male monastics have more authority and knowledge to teach Buddhist subjects to laypersons. In addition, when I interviewed other female teacher and I asked her about what she thinks about the Buddhist associations that I brought in the course content, she said that it was better to talk with a monk or a nun, evidence of the traditional understanding that monks and nuns may have deeper understanding of Buddhism compared to laypersons. Another factor of her response could be the value of humbleness and the value of controlling "arrogance" by acknowledging that they do not have the level of understanding of monks who are the ones who are dedicating their lives to deepen their knowledge and practice to Buddhist philosophical concepts. The third and final piece of evidence from my fieldnotes is that when I was looking for a school to teach my course in Dharamsala, I went to a nunnery to explain the project to the Head Nun. She explained to me that they are placing all their efforts in learning Tibetan debate because the traditional perception of Tibetans is that Tibetan nuns are not as capable as monks to engage in philosophical debate; therefore, it is my understanding that if they have internalized the idea that female *monastics* are not as capable as male monastics to discuss or teach Buddhism, *laywomen* will be even less qualified to discuss or teach it.

It seems that the perception within Tibetans in exile on the capacity of Tibetan women to teach and discuss Buddhism is changing (and will gradually change). Some evidence of this is the acceptance of empowerment programs for Tibetan nuns (Phayul

2013a; Phayul, 2013b), and the recently acceptance of the *Geshema* degree for nuns (the highest degree in the Tibetan Buddhist monastic order) (Phayul, 2012).

Others can extrapolate on these findings in the following ways: There can be forms of knowledge (e.g., "engineering") that are perceived by students as belonging to the opposite gender or to "others." If one finds students who have internalized the belief that certain knowledge is taught by (or more associated with) people of the opposite gender, it will become difficult (and perhaps impossible) to help students learn if we do not help them first to challenge this belief. In this case, teachers could implement in their teaching approach the notion of conscientization as discussed in the philosophy of education of Paulo Freire (2000) or Mezirow's stages of transformative learning that starts with a "disorienting dilemma" (Mezirow, 1991). This "disorienting dilemma" can be initiated in the form of a question that may start a reflective process that could challenge their belief that they are not capable to learn or discuss certain knowledge because of a personal identity.

5.2.8 Team 8: The repair of a garbage bin

Three team members were males and one was female. Two were 16 years old, one 18 years old, and one 22 years old. All were in class 10+1. Three were born in Tibet and one in India. They had to change their project theme twice. The first change was because they were not connecting their project to an identified problem at the school. The second change was because of time management and resources limitations. Approximately five days before the final presentation at the school auditorium, they asked me to change their project theme, and I requested they repair a garbage bin because I thought this was the simplest project they could do in five days (and it came to my mind at that moment). More information about their design projects and situation is in section 6.9.

They explained that the six virtues in general helped them in the following way:

> [The six virtues are] helping us in our teamwork. Because sometimes we became lazy, bored, and angry and it helped us.

I believe that their response and the way that they described their experience ("sometimes we became lazy, bored, and angry") stemmed from their discomfort with my lectures and the design project. The following are factors that I identified in my fieldnotes that can shed light to their superficial answer. First, as I will discuss in section 6.9, they could have felt a resistance towards the design project because I asked them to reflect on the connection of a "traditional," and thus "old," knowledge (*Mahāyāna* Buddhism) with a "modern" knowledge (engineering). Therefore, it could have felt awkward the connection between two knowledges that are perceived to be "old" and "new" respectively.

Second, some of them attended a computer tutorial lesson in the summer of 2012. I believe that the fact that I did not provide effective computer science tutorials in the summer at the school could have made them feel disappointed and resisting to my course because they already saw my failure as a teacher trying to explain a computer science topic which I honestly did not remember when they asked me about it. Therefore, this failed tutorial lesson in the summer could have made them see that I was not competent as a teacher.

Third, the politics of Tibetans-in-exile are complex. For example, there have been cases of Indian-born Tibetans who have requested Indian citizenship (Immigration and Refugee Board of Canada, 2011; Sehgal, 2014), a sign that some of them may feel the need to construct a feeling of home wherever they are living and not so much nurturing the yearning to return to Tibet (exiled with the intention to return someday). Therefore, the fact that I was associated to the efforts of cultural preservation in a school system that is connected to the efforts of the Tibetan-government-in-exile, may have created another layer of resistance in these students, especially assuming that they have been influenced by these internal politics.

Fourth, as I was told by a Tibetan youth activist in Dharamsala, there could be the possibility of Chinese government political influence in some students whose parents (or themselves) were born and raised in Tibet. Fifth, the fact that they are in a school that has the mission to nurture a Tibetan cultural identity in students does not guarantee that there will not be acculturation, especially because of the influence of the media and Internet. Lastly, it can simply be that, since they are in their transition to adulthood, they are in a "rebellion" phase of their lives, especially rebellion to what they perceive to be "traditional" and "old."

5.2.9 Summary of student teams

Table 5.1 summarizes the Buddhist concepts mentioned in the teams' report reflections. A "G" in a cell means that the team referred to the concept in general. An "E" in a cell means that the team referred to the concept explicitly, while an "I" in a cell means that the team referred to the concept implicitly. My interpretations of these findings are below the table and in section 5.5.

Table 5.1 Buddhist-*Mahāyāna* Concepts Mentioned by the Teams

Theme	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8
Six virtues (pāramitās)								
Generosity	E	E	I	I	I	I	G	G
Ethics (Buddhist morality)	E	I	E	E	I	E	G	G
Patience	E	E	I	E	E	E	G	G
Perseverance	I	E	I	E	E	I	G	G
Concentration	I	E	E	E	I	E	G	G
Wisdom	E	I	I	E	E	E	G	G
Other concepts								
Interdependence	E	E	E	E	E	E	I	
Karma	E	E	E		E	E	E	
Rebirth		E	E			E		
Equanimity	E							
Impermanence		E						

All of the teams were able to reflect on (or acknowledge) the support of the six virtues (*pāramitās*) in their design and teamwork experiences; however, some virtues per team were *explicit* and others were *implicit* or *in general*. Explicitly, the virtue most connected to their experiences was *patience* (5 out of 8 teams). In the second position were *concentration, wisdom, and Buddhist morality* (4 out of 8 teams). In the third position was *perseverance* (3 out of 8 teams). Finally, *generosity* was in the fourth position (2 out of 8 teams).

I interpret the findings of Table 5.1 as follows: *As layperson Tibetan Buddhists,* they identified some virtues to be more helpful (or relevant) than others in teamwork and design. According to Buddhism, patience is also said to counteract feelings of anger. It could be that they felt resistance toward my teaching approach because I was connecting a "modern" subject (engineering) to an "old" and "traditional" subject (*Mahāyāna-Bodhisattva* path). Therefore, they truly needed to apply *patience* to counteract their anger, an effect of *resistance*, in order to finish their projects. Certainly, what we call "teamwork" has difficulties especially when negotiating ideas; therefore, in order to accomplish their design project they applied patience as well. Three virtues were in the second position: Wisdom, concentration, and morality. Once that patience counteracts the effects of anger, they can apply wisdom, concentration, and ethics (Buddhist morality) in their process. In the third place, perseverance is applied to carry on toward the final goal.

Notably, Team 8 said in a general way that the six virtues were helping them to counteract feelings of laziness, boredom, and anger. They did not reflect on other Buddhist beliefs or concepts. I believe this demonstrates that they experienced boredom with (and perhaps resistance to) my lectures and the design project, as I will discuss in section 6.9 of chapter 6. Team 7 also reflected in a general way, and I believe that it is connected to the fact that they are girls (and traditionally in their society, male monastics are seen with more authority and knowledge to discuss these topics than females).

It does not surprise me to see generosity mentioned explicitly by only two teams because of what is possibly the perception of engineering as a "modern" profession connected to an economic system that sometimes is fueled by greed. Since generosity is considered to be an "antidote" of greed, perhaps, it was difficult for them to see generosity into what they were doing, even though I as a teacher tried to connect engineering design to the idea of altruism in the *Mahāyāna-Bodhisattva* path. Nevertheless, all the teams reflected and acknowledged the support of the virtues either implicitly or explicitly.

Regarding to the "other concepts" section of the table, six out of eight teams reflected on *interdependence* explicitly. Six out of eight reflected on *karma* explicitly. Three out of eight reflected on rebirth. One team reflected on impermanence. One team reflected on equanimity, which is considered one of the "four immeasurables" being compassion, loving kindness, and joy the other three. They acknowledged that they were reflecting on how these Buddhist beliefs and concepts were impacting their design and teamwork *from their perspective as Buddhist laypersons* (not Buddhist monastics) and in the context of their experiences.

The majority acknowledged that they and their cohorts did not receive formal Tibetan debate classes in middle school; school administrators confirmed this. Few students in their cohorts (like one of the members of Team 5) are active in learning Tibetan debate and have joined clubs to practice it. Nevertheless, the students in general participate in other forms of debate, like discussion groups and debate panels.

5.3 Engineers' reflections

5.3.1 Introduction

In this section, I review the data from the interviews of two out of four Tibetan civil engineers. I chose to analyze these two civil engineers' responses because they were the only ones who were or are practicing the profession (as determined in India). The two other engineers became mathematics teachers after they obtained their engineering degrees. Table 5.2 shows their demographics:

Table 5.2 Demographics of the two ethnic Tibetan engineers interviewed

Pseudonym	Gender	Age	Birth Place
Tibetan engineer 1	M	27	Tibet
Tibetan engineer 4	M	50	India

I examine the responses to these two questions:

- In what ways do you think that Tibetan culture (beliefs and ways of thinking) and Buddhism have been influential as you identify, understand, and solve problems related to engineering? You can provide actual examples.
- How have the [Buddhist-*Mahāyāna*] six virtues (generosity, ethics, patience, perseverance, concentration, wisdom) helped in your work? You can provide actual examples.

I coded their responses to analyze their thoughts about how the *Mahāyāna-Bodhisattva* ideal supported (or inspired) their professional engineering work. I was interested in learning how this Buddhist ideal equipped them with communication skills relevant in their engineering work, because in engineering education, there have been discussions about the importance of communication skills in engineers' work (Smith & Imbrie, 2007). From my Buddhist perspective, I saw a connection between the virtues that need to be developed in *Mahāyāna* Buddhism and the human skills that engineers need to develop to interact with others (e.g., clients, workers, and teammates, as described in my book chapter, Santiago [2013]).

From my coding, I identified three major themes in the interviews: (a) generosity, (b) patience, and (c) concentration.

5.3.2 Generosity

Tibetan Engineer 4 explained to me the importance of acting out of generosity for the benefit of workers:

> What I used to do was that whenever I had 20, 30, or 40 laborers working under me, I looked after them well.[76] And, I always thought of their problems first.

What he described relates to *Bodhicitta* or the "altruistic mind" that Buddhists who follow the *Mahāyāna* path attempt to develop gradually.

He shared with me what he did to improve his workers' wage. He preferred true-rate rather than labor-rate contracts because he could use a share of his profit margins to provide higher wages:

> That's why whenever I took any contract work, I did not take labor-rate contract….Labor rate means that the material is supplied by the owner and the engineer constructs it….True-rate contract means that you have to give both

[76] This can be a reflection of perseverance.

> materials and labor….By taking this one [true-rate contract] whatever profit margin that I get from purchasing materials, I can give the share to the laborers by providing good wages.[77]

Echoing Tibetan Engineer 4, Tibetan Engineer 1 explained that he sympathized with his workers' money situation:

> I have worked 4 years over here and I used to deal directly with the laborers…. Sometimes, they faced money problem. So they used to come to our office and [say]: "Sir, please, give me some [money in] advance." So from that part we have to keep some feeling of sympathy.

Even though the engineer used the word "sympathy," he seemed to be talking about "empathy." Research of engineering education has revealed a lack of empathic abilities among engineering students (Rasoal, Danielsson, & Jungert, 2012). Could the value of altruism in Buddhist-Tibetan culture have helped this Tibetan engineer to be more empathetic? More research is needed on this phenomenon to come up with conclusions.

Empathy can be related to compassion. In a Buddhist context, compassion is the intention and actions to relieve suffering (e.g., physical, mental, and emotional) (Mitchell, 2008). "Suffering" in Buddhism is an "umbrella term" that means not only physical pain, but also emotional pain and dissatisfaction. Some Buddhists, influenced by deep ecology, even extend the term to cover the environment (Kaza & Kraft, 2000).

Tibetan engineer 4 talked about the importance of building a relationship with your client based on trust and generosity:

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[77] This response is a reflection of ethics or Buddhist morality in practice.

> What I have found in this business is that you don't have to be very clever….*It is trust which builds a good relation with a client*. Through that client you get another client. Generally we [engineers] use to say that it is through competition that you get business. *I don't think it is through competition alone, it is the [quality of the] relation* [emphasis added].

Note that this engineer thought that the communication skills of building trust with a client, relevant to the virtue generosity, is more important than "to be very clever" and indirectly it fosters success in the engineering business. It appears that his measure of success is the quality of the relation with the client (that may lead to more clients). This finding can be evidence that the communication skills developed through his cultural background helped him to build an engineer-client relationship based on trust. This is evidence that communication skills in engineering work are as important as technical skills.

5.3.3 Patience

Tibetan Engineer 4 particularly thought that patience was the most relevant virtue of the *Mahāyāna-Bodhisattva* path:

> Patience has helped so much, for me especially, because whatever construction that you do there will always be mistakes. There will always be a mistake in that. [The] client will point a mistake from the top. Then from the bottom is the laborer, they don't work as per direction. In the middle, we [engineers] get crushed. We have to be very patient to listen to their problems. And at some point,

> so here this religious Buddhism plays a wider role of consoling oneself and not taking extreme measures.

He explained that, because mistakes in constructions are inevitable, the clients and workers will blame the engineer. It is at this point when the engineer needs patience to listen to both sides of the story and not take "extreme measures." By extreme measures, I presume that he was thinking about the detrimental effects of taking actions based on hatred, impatience, and aversion. They are considered "defilements" in Buddhism because of the possible harm that they can inflict to one's self and others (Mitchell, 2008).

His statement about failures (i.e., mistakes in construction) reminded me of Petroski (2001):

> The engineer lives and breathes failure, both implicitly through every design calculation and decision and explicitly through testing and experience. It is only by imagining failure, calculating failure, obviating failure, testing to failure, and acknowledging failure that engineers develop successful designs. (p. 322)

Petroski (2001) further noted that, often times, failures are blamed on engineers while successes are attributed to scientists. In the case of Tibetan Engineer 4, when he was blamed about the failures of his design, he found solace in Buddhist beliefs: "Buddhism plays a wider role of consoling oneself and not taking extreme measures." As discussed in section 5.2.2, Team 2 also reflected on how Buddhist beliefs helped them to acknowledge that dissatisfaction is part of *samsara* (i.e., the cycles of birth, death, and rebirth, to which we are bound according to Buddhism). In the engineer's case, I interpret his reflection as follows: The failures that he committed are not inherently his failures. He may have consoled himself by remembering that nothing is perfect in *samsara*;

therefore, dissatisfaction and failures will arise no matter how much we try to avoid them. This does not mean that Buddhist engineers have a "scapegoat" to turn to when they make mistakes. Rather, some of them might feel the need to resolve the guilt of their failures, perhaps through the Buddhist belief of *samsara*.

5.3.4 Concentration

Tibetan Engineer 1 considered the most relevant practice of the six virtues of the *Mahāyāna-Bodhisattva* ideal to be concentration:

> Of course, concentration is the main thing. When we get a target from our boss, we have to fulfill their wish.[78] We have to make some bar charts and then make a program for the work.

Concentration has helped him to deliver technical work. Although this type of concentration is not meditative concentration, he reconstructed the notion of concentration in his own engineering context by saying that the concentration helps him to make bar chart graphics and programs.

Tibetan Engineer 4 agreed that concentration was important for technical skills: "Before taking any contract work, you have to calculate the construction materials. For that you need a very good concentration." Both engineers saw an association between concentration and their technical work—especially in calculations and computer-related work.

[78] Fulfilling the wishes of his bosses can be achieved through perseverance and generosity.

5.3.5 Summary of engineers' views on Buddhism and engineering

Table 5.2 summarizes the engineers' views. A "G" in a cell means that the participant reflected in general about the concept. An "E" in a cell means that the participant reflected on the concept explicitly. An "I" in a cell means that the participant reflected on the concept implicitly. My interpretations are below the table and in section 5.5. As I said in the beginning of section 5.3.1, I chose to analyze these two civil engineers because they were the only ones who opted to practice the profession (the other two became math teachers).

Table 5.3 Buddhist-*Mahāyāna* Themes Mentioned by Tibetan Civil Engineers

	Tibetan Engineer 1	Tibetan Engineer 4
Six virtues (pāramitās)		
Generosity	I	E
Ethics (Buddhist morality)	I	I
Patience	I	E
Perseverance	I	I
Concentration	E	E
Wisdom	I	I
Other concepts		
Empathy	E	
Not taking extreme measures		E
Engineering failures are part of *samsara* (a form of consolation to resolve emotions after an engineering failure)		E

Both engineers explicitly discussed the virtues of concentration in relationship to their work. Patience was seen crucial for Tibetan Engineer 4 because he believed that it helped him to overcome problems in engineering, especially when the client or worker blamed him for a construction failure. He also connected generosity when he talked about true-rate versus labor-rate. He also believed that (a) the belief of not taking extreme measures (e.g., actions initiated by hatred) helped him to maintain peace between himself and his workers or clients and (b) the belief of *samsara* has possibly helped him to cope with the emotional aftermath of his engineering failures.

In Tibetan Engineer 4's responses, the virtue "ethics" (Buddhist morality) is implicit when he talked about true-rate contract versus labor-rate contract for the benefit of his laborers. In both engineers' responses, it is implicit perseverance in the form of assistance to laborers (or bosses, in the case of Tibetan Engineer 1). Generosity is implicit in Tibetan Engineer 4 when he talked about assistance to laborers. Wisdom is implicit in the form of "relative wisdom" (Mitchell, 2008). Patience is implicit in Tibetan engineer 1 when he talked about concentration.

The engineers' cultural background could have helped them to foster empathy, exchange themselves for others, and humanize their workers and clients. Interestingly, Tibetan Engineer 4 was able to reflect more on how the virtues helped in his work, compared to Tibetan Engineer 1. This can be a reflection of generational and regional differences of cultural identity development between those whose upbringing was in Tibet and India. It could be a generational difference, since #4 was much older than #1. I also question how the fact that #4 was born in India and #1 in Tibet could have impacted their responses due to possibly acculturation in the case of #1 (acculturation in schools in Tibet) and cultural identity development in Tibetan schools in India in the case of #4. More research should be done to determine the differences in cultural identity development between generations and regions of upbringing.

5.4 Summary about students' and engineers' points of views on Buddhism and engineering

Table 5.3, summarizes the Buddhist concepts mentioned by each team and engineer. T1 to T8 refer to "Team 1" to "Team 8" respectively. "E1" and "E4" refer to "Tibetan Engineering 1" and "Tibetan Engineer 4" respectively. A "G" in a cell means that the participant or team reflected about the concept in general. An "E" in a cell means that the participant or team reflected about the concept explicitly. An "I" in a cell means that the participant or team reflected about the concept implicitly.

Table 5.4 Buddhist-*Mahāyāna* Concepts Mentioned by Student Teams and Civil Engineers

Theme	T1	T2	T3	T4	T5	T6	T7	T 8	E1	E4
Six virtues (pāramitās)										
Generosity	E	E	I	I	I	I	G	G	I	E
Ethics (Buddhist morality)	E	I	E	E	I	E	G	G	I	I
Patience	E	E	I	E	E	E	G	G	I	E
Perseverance	I	E	I	E	E	I	G	G	I	I
Concentration	I	E	E	E	I	E	G	G	E	E
Wisdom	E	I	I	E	E	E	G	G	I	I
Other concepts										
Interdependence	E	E	E	E	E	E	I	E		
Karma	E	E	E		E	E	E	E		
Rebirth		E	E			E				
Equanimity	E							E		
Impermanence		E								
Empathy									E	
Not taking extreme measures										E
Engineering failures are part of *samsara* (a form of consolation to resolve emotions after an engineering failure)										E

All of the students and engineers found that the six virtues of the *Mahāyāna-Bodhisattva* ideal were supportive of their teamwork and design experiences; however, some virtues were talked explicitly and others implicitly or in general. Notably two teams, the team of female students (Team 7) and the team of students who resisted my teaching approach (Team 8) connected them in general (superficially). In the case of the girls, I believe that it was my failure to empower them to see that they can also reflect on these topics no matter of their gender. In the case of the resisting team (#8), I discussed possible factors in section 5.2.8; but in general, I believe that the idea of connecting a "modern" topic (engineering) with their "traditional" religious path (*Mahāyāna-Bodhisattva* path) did not make sense to them (therefore, they resisted my course and project approach).

In the case of the engineers, the engineer in his 50s was able to connect *explicitly* to *three* virtues (generosity, patience, and concentration); while the engineer in his 20s only connected to *one* of them. This could be a reflection of generational differences between Tibetans' interests and knowledge of Buddhism, and possibly ideologically-related differences within the Tibetan-in-exile community that may take effect as *resistance* towards what is considered "traditional" to favor what they perceive as modernity and progress (e.g., engineering and technology).

Nevertheless, all these Buddhist concepts ultimately are interrelated, since in the Buddhist faith it is believed that the accumulation of positive actions stemming from the practice of these virtues can lead to a better rebirth. Therefore, even if a team or an engineer was not able to reflect on them all, it does not imply that the other concepts or virtues are not relevant.

The student teams acknowledged that Buddhist philosophy concepts such as "emptiness" are beyond their understanding, although the students attempted to reflect on them in terms of interdependence. The majority of the student teams acknowledged that they were not exposed to formal Tibetan debate classes at the school. This is understandable, because the students are Buddhist laypersons who have not passed through formal Buddhist monastic education. Notably, the team of 12th graders who were the most responsive to my course (Team 2) and the older engineer who was born in India reflected on the reality of *samsara* and impermanence.

In summary, participants' responses revolved around the Buddhist laypersons' beliefs and interpretations of *karma,* interdependence, accumulation of merits through the six virtues, and rebirth; all consonant to the understanding of Buddhism among traditional Buddhist laypersons (Coleman, 2001; Mitchell, 2008). In the case of students, some showed resistance towards the project approach of connecting it to the *Mahāyāna-Bodhisattva* path; however, they all were able to acknowledge the relevance of it. In the case of engineers, there could be generational differences that may determine whether they will make more sense of these Buddhist-related topics in their engineering work.

Others can extrapolate on these findings in the following ways. The approach of introducing engineering design by connecting it to the students' cultural or religious identities may prompt resistance by some students; however, at the organizational level (e.g., school), if the organization has the value of respecting the cultural identity of the students and the mission of nurturing this identity, then this form of teaching can fit in such contexts and support their mission.

CHAPTER 6. HOW TIBETAN CULTURE INFLUENCED TEAMWORK AND ENGINEERING DESIGN

6.1 Introduction

This chapter summarizes the design process of the eight student teams and provides an analysis of the cultural aspects that influenced their design and teamwork. A finding of this research was that Tibetan culture as well as my Western cultural background influenced their design process. At the end of each team section, a table summarizes the sources of influence on the students' designs and teamwork.

The data for this chapter are derived from the students' feedback reports, my observations, videos of the classes and feedback sessions, and final project presentations. As explained in Chapter 1, to provide the students with an experience of design, I asked them to investigate a problem at the school site and design a possible solution for it. To support their design experience, I provided a feedback session for each team approximately every week. I used a progress report to contextualize my weekly feedback for each team (see the guidelines in Appendixes A to D). The duration of the course was 4 weeks of lecture and project design, plus 2 weeks to finish the project, for a total of 6 weeks. I provided an additional 2 weeks to finish their because significant extracurricular activities delayed their progress (Sports Day and HHDL's visit, both in September 2012).

Some engineering educators believe that we can help our engineering students develop themselves as professional engineers by helping them develop critical skills and decision-making skills through case-based scenarios (Allada, 2006; Johri, 2009; Munakata-Marr, Leydens, Moskal, 2009). For example, Lucena, Schneider, and Leydens (2010) published a book with a case scenario of an global engineering project for community development that showed the team's design processes along with the authors' reflective questions as examples. The assumption is that, through reflective questions, we can guide our students to develop not only the technical skills needed in engineering, but also the critical thinking skills that needed in design and teamwork.

Other scholars have noted the need to develop qualities such as patience to support teamwork (Karp & Lee, 2001; Norling, 2009). Mason (2001) argued that students should develop listening skills, especially when designing projects for communities. These nontechnical or "soft" skills are also recognized by national engineering organizations such as American Society of Civil Engineers, National Academy of Engineering, and ABET (Lucena et al., 2010).

I separated my findings about the influence of Buddhism and the influence of Tibetan culture on my students' teamwork and design process into two chapters because (a) I wanted to isolate the part of my question that attempts to understand how the *Mahāyāna-Bodhisattva* ideal impacted their teamwork and design process and (b) not all Tibetans are Buddhists. This chapter is structured in the following way. Each team's data was analyzed independently. Each team's section starts with a demographics table (age, gender, grade level, birth place) and a summary of their design project. Because I found that other factors besides their culture influenced their design decisions, including me (although not intentionally), I present a summary of these findings in a table at the end of each section. Other influencers include Indian society, Internet, my Western cultural view, my course content, and outside references (e.g., books).

It is important for me to acknowledge that, because I do not know the Tibetan language, and because language is regarded as the vehicle of culture (Herskovits, 1955), it would be irresponsible for me to say that I was able to accurately study "Tibetan culture" and see its relationship with my students' design process. Therefore, the scope of the findings presented in this chapter is limited. A deeper comprehension of the phenomena requires the perspectives of experts in linguistics and communications or of Tibetan researchers.

6.2 Team 1: The design of a garbage incinerator

6.2.1 Overview

Team 1 designed a model of a garbage incinerator (see Figure 6.1). Even though there was a waste incinerator at their school, they thought about designing a way to catch and filter the ashes. The four students were male, in class 10+1, and born in Tibet (see Table 6.1).

Table 6.1 Demographics of Team 1

Gender	Age	Class	Birth Place
M	22	10+1	Tibet
M	20	10+1	Tibet
M	20	10+1	Tibet
M	19	10+1	Tibet

Figure 6.1 Incinerator designed by Team 1

6.2.2 Design process

As part of the process of investigating the problem, Team 1 wrote the following problem statement in one of its reports:

> One of the needs is an efficient and easy way to segregate garbage and burn the rubbish. A simple and easy way to clean because it [the garbage] will stay at the [school]. As in our school there is a lot of garbage produced by the people who stay here, it's very difficult and hard for the children to clean it. There is no

proper place to burn it. Therefore, there is a need of a proper place and machine to clean the ashes and segregate the garbage.

Because the majority of the teams had difficulty identifying problems at the school, I provided them with examples of problems that I observed at the site, the majority of which related to children's welfare, which is an area of interest for me. Their statement that "it's very difficult and hard for the children to clean it" leads me to believe that my Western perspective influenced the team's investigation of the problem. Ransom (2006)found that Tibetan children in nomadic Kham (a region of Tibet) often do work according to their family roles in the society. In this case, as nomads and pastoralists:

> When the sun rises in the morning, the mother wakes up and makes a fire in the stove. Not long after that, the children wake up and begin their day. With the children's help, they start tending to the animals. An important task is milking the [female] yak [known as "*dri*"] early in the morning. During the early morning, the father is still asleep. After tea is made, the father wakes up for breakfast with the family…. After breakfast, the family herds the animals onto the mountainside. Often times, it's just the older children that are responsible for doing so. The children also help with making food, such as butter and cheese, and assist with collecting yak dung which they burn to keep the fire going. (p. 2)

Even though my Tibetan students live in India, 23 out of 33 of them were born in Tibet. Of those born in Tibet, five self-reported that they were born in Amdo or Kham, regions of Tibet where there are still people who have experienced or have lived a nomadic life. Because of their sociocultural background, it is unlikely that they have thought that those tasks done by children at the school are "difficult" and "hard," as we may consider them in some Western contexts. Therefore, I believe that my Western view and power as a teacher influenced the team during the design process. It is important to be mindful that one's cultural background will inevitably influence the students' design process. Students do not design in a "bubble," but in a context, and sometimes that context is influenced by the teacher.

To justify the importance of the problem, the team connected it to the students' health and the broader society. This reflection was fostered by questions that I added in the report guidelines to help them reflect on how their problem connected to society (see Appendix A to C):

> [Garbage] causes a lot of problems to society. First of all, it affects the health of people [and can] cause environmental problems, which leads the community to spend time [to] clean it. Which causes another community to criticize other community and the leader or association to put pressure on the citizens living at that particular area.

The students believed that solving the problem would be valuable to avoid other community's critiques and reduce the time spent cleaning the environment. Their concern about the criticism of others could be a reflection of the collectivistic side of Tibetan culture, although this has been changing because of the influence of Western cultures (Benz, 2012).

Figure 6.2 shows the design that the team included in Report 2, which was very similar to an image that they found on the Internet (although, they forgot to cite the source). The design includes a filter on the opening of the chimney, but it was unclear to me whether the filter's purpose was to trap ashes, carbon dioxide (CO_2), both, or neither.

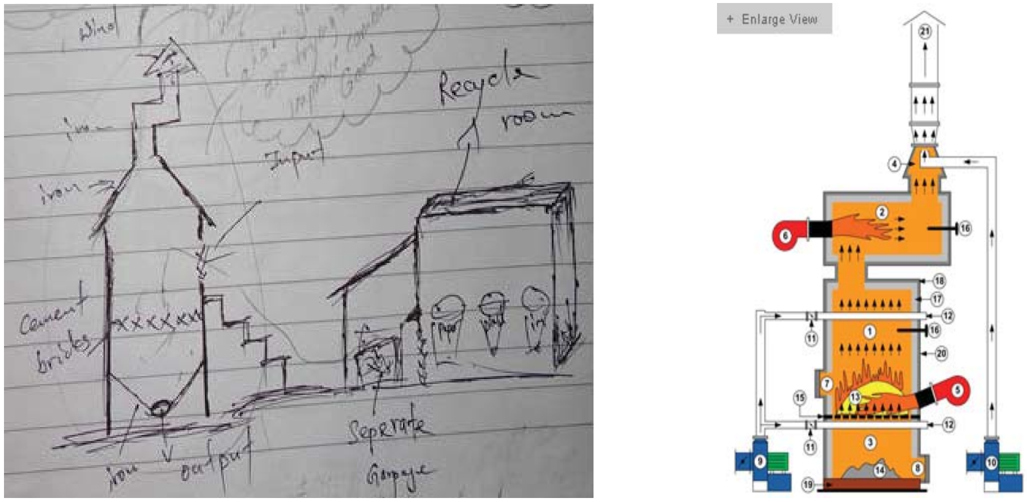


Figure 6.2 Their design drawing and image found on the Internet

To justify their choice for a final design idea, the team members wrote:

> Because [of] our team's problem investigation, we came to know that it is the best design for our school; because it does not require expensive materials to build it. It is easy to clean and will take less time to burn the garbage. It will help the students' health because it will avoid wounds by broken glass.

Based on their investigation, the team members concluded that their design was appropriate because it is (a) inexpensive, (b) easy to clean, (c) takes less time than the current procedures to burn the garbage, (d) may prevent (respiratory) health problems, and (e) may avoid wounds. These examples mirrored the "design justification" examples that I shared during feedback sessions and in report guidelines. My examples (see bottom section of Appendixes A to C) used the engineering design for industry information acquired from engineering-related books and Web pages from an American context (see a list of the textbooks that I used for my course in Appendix BB).

The team members confused “requirements of design” with “materials to make the models.” They listed the materials that they would need in order to make their models: plywood, hammer, iron sheets, and a cutter. They valued the knowledge they acquired observing others welding and using cutting machines at the Tibetan Vocational Training Center (VTC) campus.

After the team members presented their project in the school auditorium, I went to the table where they placed their model. They explained how their design worked. They designed a storage area to segregate waste. They divided the outer storage in “paper,” “bottle” (e.g., the plastic bottles that I observed at the school), and “others” (e.g., metals).

Figure 6.3 Model of a garbage incinerator and garbage segregator

According to the team leader’s explanation, the garbage would be placed in the rock pit, presumably to facilitate the transportation of the garbage to the incinerator. He explained that the school’s current incinerator has a surface where the garbage is placed and a ground where the ashes will fall. When it is windy, the ashes are dispersed into the air. The students thought that by having a tray underneath the surface where the garbage is placed would make ash removal easier. It was unclear to me whether they thought that even in this way the wind would disperse the ashes when the incinerator was opened. In addition, it was unclear to me whether they realized that the metal tray would get hot, thus causing a safety issue for the children. If this model were to be implemented in real life, it would not solve the problem of ash dispersion into the air and the hot tray would burn the children’s hands.

Once collected in the tray, the ashes would be deposited in the school’s ash pit. The air filter would catch any ashes dispersed in the air while the garbage was burning. It was unclear to me how this would happen if there a space existed between the ash filter and the top chamber (see Figure 6.4). Therefore, this other design feature probably would not solve the problem as well. As discussed later in the sections for Teams 4 and 5, these teams helped me to reflect on (a) the boundaries of problem solving and (b) the reality that sometimes engineers end up creating more problems than they solve.

Figure 6.4 Speaking about how their design will trap the ashes

6.2.3 Summary

Table 6.2 lists the sources of influences identified in their data: (a) ideas that I shared with them, (b) a design of an incinerator found on the Internet, (c) my course content, (d) the help of others at VTC, and (e) awareness of the waste management problem in India.

Table 6.2 What Influenced the Design of Team 1?

	Indian society	Tibetan culture	My Western view	Internet	Course content	Books and magazines
Ideas I shared throughout their design process			✓			
A design of an incinerator that they found on the Internet				✓		
Design for industry information					✓	
Help of others at VTC		✓				
Their awareness of the waste management problem in India	✓					

The school's garbage management problem is indicative of what happens throughout India. In India, garbage management is a significant problem and has been reported by other authors (Sharholy, Ahmad, Mahmood, & Trivedi, 2008). Garbage burning is not limited to homes, small businesses, hostels, residences, and schools such as TCV. In the case of e-waste, people who wish to scrap metals in order to sell them often burn e-waste or immerse the e-waste in harmful chemicals to separate the metals from the non-metals (Pellow, 2007). Despite the Basel Convention Agreement, companies in developed countries still send their e-waste to India (and other developing countries) to reduce their business expenses (Mundada, Kumar, & Shekdar, 2004; Nnorom & Osibanjo, 2008). Therefore, their chosen problem could also be happening in other schools in India.

6.3 Team 2: The design of a load carrier

6.3.1 Overview

Team 2 decided to work on a solution to help children move sacks of vegetables to their respective homes (residences). The team consisted of four male students and one female student, and all were in class 10+2 and were born in Tibet (see Table 6.3). The team was inspired by a design of a load carrier by V. Panchal (Singh, 2011), found on the Internet. A main feature of the cart was that it can be used as a cart or back carrier (see Figure 6.5).

Table 6.3 Demographics of Team 2

Gender	Age	Class	Birth Place
M	19	10+2	Tibet
M	18	10+2	Tibet
M	18	10+2	Tibet
F	20	10+2	Tibet
M	18	10+2	Tibet

Figure 6.5 Load carrier designed by Team 2

6.3.2 Design process

The team’s problem statement was written as follows:

> Every week the school buys vegetables for the homes and two hostels. Since hostels have many students, the sacks are full and the workers put those sacks of vegetables at the hostel doors (near the lanes).… During the break time, the students carry them [sacks of vegetables] to their homes, but they face many problems while doing it.

As with Team 1, I believe that my Western view of proper tasks for children influenced the team’s design process. I observed that, in the school’s context, this type of work is something that children often do as part of community service; thus, they do not view it as improper work for children. In addition, the students took an idea from a design by V. Panchal (Singh, 2011). It is understandable that the students selected a design suited for a rural Indian context, because they are living in rural India and they have to consider their current reality.

The following is a transcript of their final project presentation. I edited the grammar to improve the readability. This is a complete summary of their work and therefore serves as an introduction:

> At first, we got 4 to 5 designs. In the first stage, every team member gave a design. We collected all these designs and we all gathered together. We discussed. We took ideas from different designs and finally we combined all of our ideas into the final design. Initially, the model was completely made of bamboo. All things were made of bamboo, and suddenly a team member thought that, 'oh, what about the chairs? We can reuse a broken chair.' We thought of using the chairs because we are recycling. We are contributing to our mother nature.

To summarize, each member contributed an idea. The team members examined the ideas and selected the best characteristics of each design. They considered reusing materials and selecting biodegradable ones to meet the sustainability requirements that I made compulsory in every project.

The following quote is from the female student who summarized how they implemented the design cycle model that I proposed in class and highlights the team's experiences. It is a transcript from the video that I took at their final project presentation:

> The most important experience that we had is that we did a real engineering design project. So, it involved a real engineering workshop in which we went

through all of the four phases of an engineering design project. That is: first we understood, first we find our problem and understand the problem. And the second, we find causes and conditions and we find solutions. And third, we selected the best model to solve the problem. And the last, the fourth, is the most important, we tested the model and we can do modifications, we can do redesign to the model. We built relations, friendship, and communicated with others while we needed help. While we are working in a team, different people have different opinions and ideas about problem-solving solutions, so we respect each others' opinions and we worked hard. And then, while we, a long time after that we had some refreshing snacks and then we [inaudible]….And the third, additional apprenticeship that we gained is that we worked in the VTC carpentry workshop. So during that time, we learned lot of new things. For example, we learned how to cut woods with a saw, and we learned how to make holes in the bamboo, and we learned how to make smooth surface with that machine, and we learned a lot…. So it was a totally new experience. And we also saw the working conditions of the students in the workshop [VTC]. So, it was a very new and beautiful experience.

To summarize, the team members understood the design cycle as (a) finding and understanding a problem, (b) finding causes and conditions, (c) selecting models, and (d) testing the design. They (a) built relationships while engaged in the project (evidence of community engagement), (b) mediated the different opinions of the team members, and (c) used the VTC facilities to implement their design.

They wrote the following to explain why the problem arose at the school:

> Our problem arose because [the] school has [a] shortage of workers…We need the vegetables to eat. Their [students'] study and survival depends on these foods, so everything is interrelated. Nothing exist independently, so as the problem can be also solved by depending on a tool (of someone's idea).

Even though it is impossible to analyze all of the circumstances of a problem, the students mentioned a possible cause (lack of workers at the school), the circumstances (people's survival depends on transporting the food), and a solution to address it (a tool). Their reasoning reminded me of the notion of "dependent origination" of the *Madhyamika* philosophy school of *Mahāyāna* Buddhism. Gyatso (2006) contextualized the reasoning of the notion of dependent origination to the design and implementation of the first car:

> Consider the person who made the first car. First he had a concept of what he wanted to invent. Then he set about making it. After a few prototypes perhaps, he finally made something which fulfilled his concept. It was able to perform the function of the object he had in mind in the way intended. At this point he designated what he had made as car. All the other cars that have come into the world since then are apprehended in the same way. On the basis of an appearance to mind of the assembled components that are able to perform that particular function the mind imputes, car. What can we say of the ultimate nature of a car other than that it is devoid of any existence from its own side, in the first place because it depends on causes and conditions, in the second place because it depends on its parts and in the third place because it depends on the three, a base

> of designation, a conceptual mind which designates it and a term to designate it by? (p. 62)

This team was the only one that used published information about a material (bamboo) to justify its use. It also provided a bibliography at the end of the electronic presentation. It referenced the following information from an encyclopedia to justify the use of bamboo:

> Our materials are bamboo, steel wheel, iron bar, and a broken chair. Bamboo (Ref: The World Book Encyclopedia, 2.B, page 51): Bamboo is a grass family species and it's noted for usefulness of hollow woody skin. We need bamboo for our design because experts compared the strength of laminated bamboo with soft steel. They found that it's breaking point is almost equal. It's locally available too. An iron bar is strong enough to support the weight of approximately 50-60 kg. A steel wheel is firm, it won't worn out easily by friction. A broken chair: reusing the useless chair to support our load.

The school has bamboo plants, and I realized that the team could make use of the stalks, because authors Bhatia and Smith (2008) have listed them as a strong biodegradable material that can be used in engineering design. However, the stalks are difficult to cut and my students did not have proper tools, so this was a difficult task for them. For future interventions similar to mine, I recommend that the teacher make a budget for age-appropriate tools and materials.

6.3.2.1 Design testing

As an introduction, I would like to highlight what the Team 2 members said about their design testing experience. These data were derived from a transcript of their final project presentation. The student who talked at the final project presentation emphasized that they learned how important is to test a design because it is in this way that one redesigns:

> Actually, the testing phase of our project was a very important one because, while testing, you can know whether or not your product is satisfying those who need the help. So, yesterday we tested our model with home students. They had tested it, but it wasn't working. And our instructor madam [Marisol] said that it is okay if it's not working. We faced what real engineers face, because when a product is not working well, and it is not good for the user, then we have to redesigned it and make it useful. So our wheels were too small and we installed bigger ones and we put a sponge on the back to make it softer.

With the load carrier constructed, the students went to a children's residence to determine whether their design was suitable for the children's needs. The home mother (the lady in charge of the children's residence) gave a rice sack to the team. They put the rice sack on the load carrier, and the home mother even helped my students set up the sack on the cart.

A boy tested the load carrier. He made an expression of discomfort when he stood up: Either the load was heavy or the cart design itself was not comfortable for the back of a child. The boy walked from one home to another. The girl on the team translated the boy's opinion about the design: "He said it's not heavy. But he is feeling shy." She also said, "Actually, we need bigger tires. The wheels should be a little bit bigger. Right now the wheels, hmm, are smaller for that [inaudible]. Because if it goes on a rough road, then there will be obstacles."

The second part of their testing was to test the load carrier as a cart. Another boy volunteered for testing. He configured the cart (put on the handle extensions) with the help of the team leader. When he started to push the cart, the rubber strap around the wheel axle came loose. With a lot of difficulty, he was able to move the cart. I noticed that the ends of the bamboo handles were touching the ground. One of the team members started to explain what was happening with the wheels. This student felt shy when I started to film him. I didn't want to discourage him, so I promised I would not point the camera at his face. This helped, because he started to talk again:

> So when [the rubber] is rubbing too much, it heats and it gets elastic, elasticity [a team member corrected him with "expand"]. Then it expands and it becomes loose. [Inaudible]. So we thought of putting high heat capacity things, like iron or something else instead of rubber. It will be better…. They are also suggesting that this [bamboo stick] is quite painful. So we are going to put some sponges [on the back].

He explained what was happening using his knowledge of physics and his English level skills. The team realized that (a) the rubber expands when it gets heated, (b) when the rubber expands it comes loose from where it is attached, and (c) placing a material that can absorb the heat would prevent the rubber from expanding. Because of these testing experiences, the team members modified their design to include a sponge in the back of the carrier. They also exchanged the wheels for bigger ones provided by a school teacher (see Figure 6.6).

Figure 6.6 Modifications to their design: A back support and bigger wheels

6.3.3 Summary

As with the other teams, Team 2's design and teamwork were not only influenced by Tibetan culture, but also by the following aspects (see Table 6.4).

Table 6.4 What Influenced the Design of Team 2?

	Indian society	Tibetan culture	My Western view	Internet	Course content	Books and magazines
Ideas I shared throughout their design process			✓			
The course requirements: Compulsory to address "sustainability"					✓	
Way that they described the causes and circumstances of the problem (using the logic of dependent origination)		✓			✓	
Bamboo information					✓	✓
Design by V. Panchal	✓			✓		
Help from VTC and the school community		✓				

As explained above, I believe that my Western view influenced the team's decision of which problem to select because, to help them in the decision process, I suggested something aimed to help children. Also as explained above, in traditional Tibetan nomadic societies, children often do work that can be considered too hard by Western-American standards. This is evidence, therefore, that my suggestions ended up being reflected in their project. The course project made compulsory the reuse of materials and the support of sustainability. The logic that the students used to describe the causes and circumstances of the problem reminded me of the notion of "dependent origination" that I presented in the course content and that they had heard of in their Buddhist society. The course content referenced bamboo, and the students looked for information to justify their decision to use this material. They took inspiration from a design suitable for an Indian village context by V. Panchal (Singh, 2011), and photos of this design were found on the Internet. Finally, they engaged with the community by seeking help from a home mother (residence manager), VTC staff, children who participated in the testing, and a teacher who loaned old wheels from a children's bicycle. Therefore, the students were influenced by an intersection of sources and cultures.

Tonso (2006) conducted an ethnographic study to understand the teamwork and campus culture of two student design teams in an engineering program. She found that the successful teams practiced egalitarian values:

> Good teams at all levels practiced egalitarian relations, especially respecting that each student led a complex life comprised of in- and out-of-school commitments, that each had something to offer to the team's work and must contribute in meaningful ways, and that hearing out alternative approaches provided a key way to learn about one another's expertise. Teams that took one another seriously, also always took their engineering practice very seriously, especially making sure that they really understood their client's needs and their response to it. Thus, teams-that-worked promoted egalitarian social relations contra campus preferences for competitive arrangement. (p. 35)

Consistent with previous research (Tonso, 2006), I believe that the Team 2 members succeeded in their project because they practiced egalitarian relations in teamwork and took extra efforts to understand the children's needs by the means of testing their design with actual children who volunteered.

6.4 Team 3: The design of a portable cart

6.4.1 Overview

Team 3 worked on a portable cart to move cut grasses, which also aimed to help children (see Figure 6.7). As shown in Table 6.5, the team consisted of four males in class 10+1. Two were born in Tibet and two in India.

Table 6.5 Demographics of Team 3

Gender	Age	Class	Was born in
M	17	10+1	Tibet
M	17	10+1	Tibet
M	16	10+1	India
M	17	10+1	India

Figure 6.7 Portable cart designed by Team 3

6.4.2 Design process

When I first interacted with this team, a team member asked me if they could work on a project in which they proved the physics concept of rotation. I told him that the project is similar but not the same as a Science Day project; thus, rotation could be part of, but not the entire focus of, their project. As an example, I said that if they decided to design a new window for their classroom, then they could argue that rotation is one of the physics concepts associated with their design. From a constructivist learning perspective (Chi, 2008; Svinicki, 2004), the student compared the new information (a design project) with his concept of a Science Day project in an attempt to assimilate it; however, he found out that both concepts were alike but not the same. Thus, after my explanation, the student had to create a cognitive structure to accommodate the new information about what is (and what will be experienced in) an engineering design project.

Because this team was also having difficulty identifying a problem, I provided examples of problems that I saw at the school, including the need to design transportation methods to carry loads. The team members said that they developed ideas from the Internet, a magazine from India, and textbooks published in India. As with Team 1, they did not acknowledge (or forgot to note) the Web pages where they found the ideas (they only stated "Google" and "Wikipedia").

When the team members submitted their first report, they decided to interview a class 10+1 student, who incurred a small injury when moving cut grasses. Therefore, they were considering a cart design to help his work. They provided a summary of their problem statement in the final project presentation:

> Most of the students in our elite school face several problems while they are cutting grasses and displacing them to other areas as the weeds contain lot of thorns. Some of our friends had shared their view-point about the need of a portable wheel cart to transport the weeds in an efficient way.

I question to what extent this team was also influenced by these other factors and not just by their friends and their problem investigation: (a) my Western definition of problems, (b) their Buddhist view that certain problems are a normal part of *samsara*, (d) the community did not have the resources to solve the problem before, or (e) problems could be seen as opportunities to develop strength. Furthermore, it seems that their problem statement was influenced by a problem statement example that I included in the design progress report guideline #1 (see Appendix A, section IV: “Examples of Problem Statements”), and that had to do with designing a device to facilitate the transportation of grasses.

Identifying design requirements were part of the project, although many of the students struggled with this task and I ended up suggesting some ideas to them. This team identified the following design requirements: (a) the design should carry loads of 5-6 kilograms, (b) weight without load should be approximately 4 kilograms, (c) must be customized for an 8-year-old student, and (d) should be user-friendly and eco-friendly. The user-friendly and eco-friendly terms were included in my course materials. After I asked them to be more specific about the capacity of the cart, they specified the load, what it should hold, and the age of the user. I noticed later that, although they interviewed a class 10+1 student, they switched to a design that would help an 8-year-old, again perhaps because of my Western influence about proper work for children.

Identification of design constraints was also part of the project. The students and I had difficulty understanding the difference between requirements and constraints. The team listed the following design constraints: (a) maximum expense of 100 Rupees (approximately $2), (b) most of the materials must be found at the site, and (c) within 5 minutes or less a child should move the load from the canteen to the boys' hostel. When explaining the design features, as expected, they used the term "design for industry" that I included in the presentation (e.g., sustainability, efficiency, and eco-friendly):

> The design model is based on efficiency and sustainability. We don't have to consume natural resources, which makes our design eco-friendly. It has big and light wheels, which makes the model portable. Our reused wheel is made up of plastic, so it should be able to endure the thorns and nails or any rocky path. It is like an ATV (All-Terrain-Vehicle) which can go on rocky, smooth, and grassy area. We can fold the cart as well, which makes it portable.

Their responses made me reflect on the following: How can I make sure that the students really understand the meaning of terms such as eco-friendly and efficient? Are they using the terms because I am the teacher and they need to "pass the course" just like any other course?

The students identified that the teacher (me), the teacher's report reviews, and others at the school helped them in their project. They decided to implement the portable design among their alternatives because it (a) was user-friendly, (b) had the capacity to hold more load, (c) reused wood, and (d) was inexpensive to build. Of these reasons, I did not find evidence to support the design's user friendliness and the capacity to hold multiple loads. The team members believed that the most difficult part of the project was to search for materials (like the wheels) because not all of the materials were available at the school. They reported that they learned about the following experiences: welding, carpentry skills, time management, work distribution, and stitching fabrics.

6.4.2.1 Design testing

This team was one of the three teams that had a testing phase, which was one teaching method to help the students to see that design is an iterative process. However, because of personal and time limitations, I could not help all eight teams with a testing phase.

The day after the final presentation, I invited the team members to the classroom to test their design. I planned a simple test: Observe what happens when one puts grass in the cart bag. Two team members arrived and set up the cart (see Figure 6.8). Two thin sticks supported the base of the cart. Taped plastics held the sticks to the bottom of the cart. Two pink straps from a used bag served as the connection points of the two pieces of plywood that made up the bottom. The students stitched three rice sacks to hold the grass.

Figure 6.8 Setting up the cart

At that time, there was lot of cut grass behind the administration building and other areas. The students and I went outside to put grass in the cart. After the third load of grass, the cart broke (see Figure 6-9). The students performed a quick repair to the cart by putting more tape on the wood sticks, but it was not sufficient to support the grass load. In the end, we discussed the possibility of using other materials, and they thought about redesigning the base. I did not follow up with the team because my allowed time to conduct research at the school site ended.

Figure 6.9 Examining the cart

6.4.3 Summary

With a great deal of effort, Team 3 designed a portable cart out of reused materials to help children move cut grass. As shown in Table 6.6, the data revealed the following influences in their design process: (a) my Western view, (b) the Internet, (c) my course content, (d) their collectivist aspect of their culture, and (e) books and magazines published in India.

Table 6.6 What Influenced the Design of Team 3?

	Indian society	Tibetan culture	My Western view	Internet	Course content	Books and magazines
Ideas I shared throughout their design process			✓			
Engineering design information					✓	
A problem statement example in the design progress report guideline #1					✓	
Help of others at the school		✓				
Ideas found on the Internet (unknown)				✓		
Textbooks and magazines from India	✓					✓

6.5 Team 4: The design of a dog catcher

6.5.1 Overview

Team 4 decided to work on a solution to help students catch dogs (see Figure 6.10). The team consisted of two female and two male students. As shown in Table 6.7, all were in class 10+1. The females were born in India and the males in Tibet. The males were several years older than the females.

Table 6.7 Demographics of Team 4

Gender	Age	Class	Birth Place
F	16	10+1	India
F	17	10+1	India
M	21	10+1	Tibet
M	19	10+1	Tibet

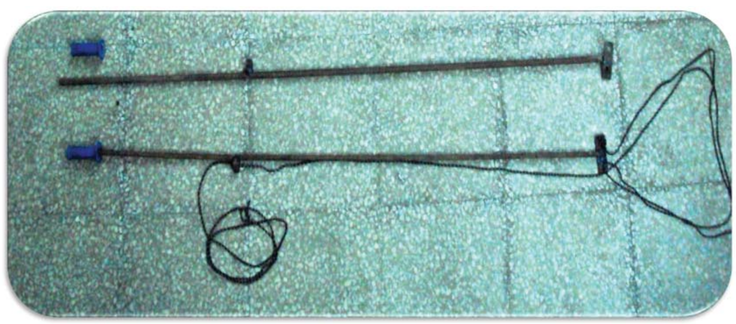


Figure 6.10 Dog catcher designed by Team 4

6.5.2 Design process

Initially, team members created different designs for a dog catcher. Their first idea was a cage with a method to attract a dog. Their second idea was a long stick with a rope loop at the end that could be used to catch a stray dog. Finally, their third idea was a tool to catch a dog by tying its legs. In one of the reports, they wrote the following problem statement:

> There are lots of dogs hanging out in this school and no one knows whether they could be dangerous. A bite could lead to death. Dogs bite could cause rabies, which is difficult to cure, and surely more cost would be needed to cure it. Not only this, but dogs even bark during the night which disturbs the sleep of students.

They justified their selection by arguing that dogs at the school campus might transmit diseases and therefore should be caught. The school administration told me that they do not have the money to spay/neuter dogs. As a consequence, they have a proliferation of dogs on campus. This focus on health-related risks aligns with my guidelines to reflect on the social and health consequences connected to the problem. From my observations in the field, dogs are not seen as a problem, unless special guests come to campus or special events are held on campus. In addition, it could be that their problem statement was modified from a problem statement example that I included in the design progress report guideline #1 (see Appendix A, section IV: "Examples of Problem Statements"), and that had to do with designing a device to catch dogs.

In their final project presentation, the team members referenced an online article in the *Times of India* about the number of people in India who die every year of rabies. They cited Google as their source of information online but did not specify the information of the Web pages. They said that they used the VTC facilities to weld.

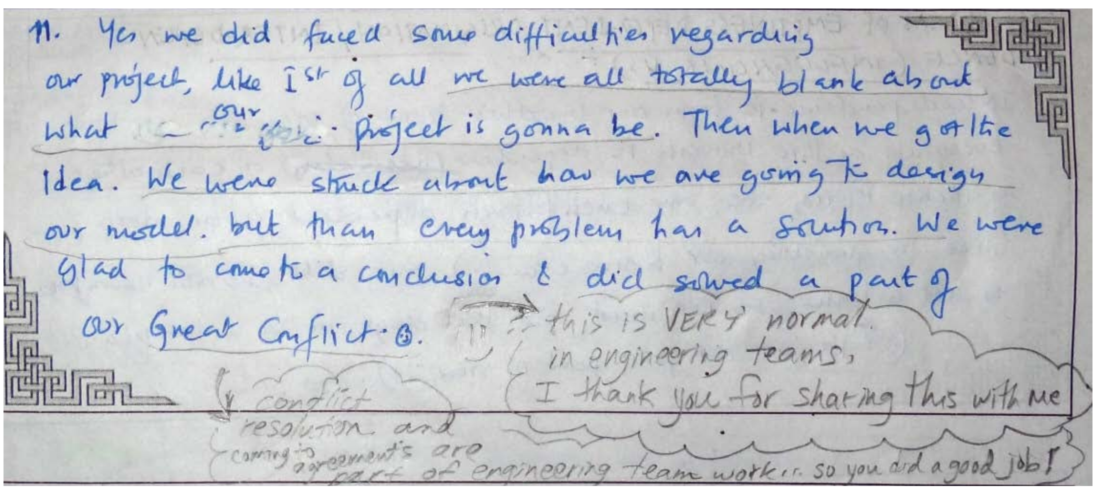
Like Team 1, Team 4 was confident that its design would produce the expected output. The team members thought that their design would not harm the dog but did not provide justification as to why: “We are sure that these [designs] will not harm the dog as well as humans,” they wrote in Report 2. In a feedback session, the team leader justified this statement by saying that he was a dog catcher in his previous school and he had experience designing the tool before in class 10.

According to the reports, the team members experienced difficulty in (a) finding a project that would benefit the school and be safe for them to work on, (b) brainstorming design ideas, (c) designing a harmless dog catcher. Regarding the first difficulty, one day after the class the team went to my apartment at the school site. The team members were convinced that the dog catcher design would lead to a dog bite, as I mentioned during the feedback session on that same day. One of the girls explained that they were having difficulty reaching agreement about the project. I decided it was time for me to help them identify other problems because they were clearly challenged by this task.

An alternative idea (from another project) came to my mind—the design of a mop. During my stay, before teaching the course, I saw that one of the *shenpen* teams at the school was responsible of making mops. They cut old shirts into strips and tied them to the end of a long bamboo stick. I suggested that they interview a *shenpen* team member responsible for the mop-making process and then try out several different fabrics (materials) to determine which one can mop a wet area within a period of time (e.g., 5 minutes or less).

In that moment, I observed that the girls agreed with this suggestion. When I received Report 3, I expected a discussion of the mop design project, but the team had reverted back to the original dog catcher design project. Although I do not have evidence of it, it seems to me that the girls agreed with the mop design and the boys disagreed to do it perhaps because the boys perceived a threat to their masculine identities (Swan, 2012) stemming from a gendered artifact associated with women's household chores. The boys, because they were older than the girls, could have thought that the project was not appropriate for their ages as well. This is my musing, because the team members did not share with me why they reverted back to the dog catcher design project.

When the team members wrote about their teamwork difficulties, they stated (a) "we were all totally blank about what our project is gonna be" and (b) "we were stuck about how we [were] going to design our model." However, it appears as though they reached a compromise because they wrote: "But then every problem has a solution. We were glad to come to a conclusion & did solve a part of our Great Conflict" (see Figure 6.11).


11. Yes we did faced some difficulties regarding our project, like 1st of all we were all totally blank about what our project is gonna be. Then when we got the Idea. We were struck about how we are going to design our model. but than every problem has a solution. We were glad to come to a conclusion & did solved a part of our Great Conflict ☺.

this is VERY normal in engineering teams, I thank you for sharing this with me

conflict resolution and coming to agreement's are part of engineering team work.. so you did a good job!

Figure 6.11 Team's difficulties

The comments in "bubbles" were my style of expressing my written feedback in their reports. In this case, I wrote two comments: "This is very normal in engineering teams. I thank you for sharing this with me" and "[c]onflict resolution and coming to agreements are part of engineering teamwork…you did a good job!" Both commentaries highlighted their teamwork process of agreeing on the design idea to develop and implement. Although this team (half boys and half girls) faced a lot of challenges in teamwork, its members persevered and passed through their design experience.

6.5.2.1 Gender dynamics

This team divided some tasks by gender roles, as described in one of their reports:

> Honestly speaking, we only met twice [in the week], and we distributed our work like *both of girls will write the report & the boys will start making the instrument*. And they (boys) will keep us updated on their work progress: And *we girls would be updating the reports to you* [emphasis added].

In engineering education research, Swan (2012) drew from Bronfenbrenner's (1979) ecological systems theory to explain the experiences of women in introductory engineering projects in higher education institutions in the United States. Aligned to my findings, she also found that some teams divided their tasks according to gender roles; therefore, there could be a cross-cultural aspect to this scholar's research as well:

> Regardless of whether labor was divided equally or unequally among project team members, tasks were often divided along gender lines on mixed-gender project teams. While most female participants on mixed-gender teams at all three institutions participated in building or physical assembly tasks, male team members at SCC and SU were more likely than female team members to perform technical tasks such as programming and electrical assembly. The reasons for this

phenomenon included prior skill sets, as well as female students' perceptions of their own abilities. (Swan, 2012, pp. 348-349)

In addition to gender roles expectations, Johnson and Schulman (1989) found that, in groups of four persons (as Team 4), "task activity for both women and men differed as the proportion of their own gender in the group decreased, for both, conforming more closely to stereotypical gender expectations" (p. 370). In the case, the team was composed of two men and two women. Although the team had a gender balance, its activities were divided by gender roles (boys implemented the design while girls focused on answering the reports). Thus, in this case, two of each gender appeared to have the same effect as if there had been only one woman in the group. Other factors of cultural gender norms and roles could have played a role in this case. More culturally specific research is needed.

I am aware that at least one of the girls was more interested in biology (the "medical stream" emphasis at the high school level) than engineering. One of the boys said that he was interested to pursue software engineering, while the other one said that he was interested in "science and math." It could be that they both were frustrated that my course neither included math nor software engineering.

The age difference could have impacted this team's dynamics: the girls were ages 16 and 17 years and the boys were ages 19 and 21 years. It is not clear to me whether the facts that the girls were Tibetans born in India and the boys were Tibetans born in Tibet were significant to the team's dynamics. Future research should take into account how team leadership is defined and viewed in conjunction with gender roles and norms in

Tibetan society in exile in India. I encourage ethnic Tibetan scholars to bring their perspective as well.

In the presentation feedback session, I tried to learn how they were managing teamwork. The girls were not comfortable sharing their teamwork experiences with me, so I did not press the issue. I speculate that they were uncomfortable because other students were in the classroom—this was not a private venue. In addition, the fact that I am a woman or that I associate myself with Tibetan Buddhism does not change the reality that I am a *Westerner*; therefore, in my teaching context the cultural-ethnic identity of the students was a stronger (and legitimate) boundary that made them to perceive me as an outsider.

Only one team member (the leader) gave the final presentation on stage. He spoke in Tibetan. He did not present the dog catcher on stage. I did not ask him why at that time, but the next day, I asked him to demonstrate the dog catcher in a testing phase to determine the final outcome. After the testing phase, I presumed that he was reluctant to show the dog catcher because it was not working as expected, and if he had shown it in the school auditorium, he might have been the subject of laughter.

6.5.2.2 Design testing

During the test, I wondered how they would be able to catch the dog if the end of the hook was not firm. The team leader explained that they wanted to use a thicker rope, but could not find a suitable one. I asked him to look for a dog on the campus. Other students said that there was a dog on the terrace of the high school, so we went there.

Figure 6.12 Testing the dog catcher

As shown in Figure 6.12, the design was not effective. Nevertheless, I wanted to provide the student with the experience of a testing phase to help him to understand that engineering is not only design and implementation, but also testing in a simulated scenario to determine the design's success. In addition, I wanted to see whether he would brainstorm ideas about improving the catcher.

I bent the end of the cord to form a circle. I did not believe that the cord would prevent the dog from escaping. The metal stick was a construction beam and therefore strong enough for the purpose. I was aware that the team did not use the right materials, but I suggested that any redesign should consider the type of cord and the mechanical processes to aid the catching. As with the other teams that had a testing phase, I was not able to follow up because my time at the school site was running out.

6.5.3 Summary

As shown in Table 6.8, this team was influenced by (a) the ideas that I shared throughout the design process, (b) my course content, (c) help of others at VTC, (d) gender dynamics, and (e) an article from the *Times of India* and information from the Internet.

Table 6.8 What Influenced the Design of Team 4?

	Indian society	Tibetan culture	My Western view	Internet	Course content	Books and magazines
Ideas I shared throughout their design process			✓			
A problem statement example that I included in the design progress report guideline #1					✓	
Help of others at VTC		✓				
Gender-related team-dynamics		✓				
Article in the Times of India and unknown information taken from Google Web searches	✓			✓		

As with Teams 2 and 5, this team made me reflect on the consequences of asking students to solve a real problem. If they catch the dog and put it outside of the campus, then it will likely return to the campus. The problem is *temporarily* solved, but in the long run it might create more problems outside or inside of the school. Downey (2005) argued that the image of engineers as problem solvers is problematic in itself, because the moment that we include people in the problem-solving process, the problem is no longer just technical, but human as well:

> One way of acknowledging the core human dimensions of engineering work is to recognize that engineering problem solving has always included the activity of problem definition. In carrying out their work, engineers necessarily negotiate and re-negotiate the definitions of technological problems both among themselves and with non-engineers. Accordingly, one potentially promising way of remapping the jurisdiction of engineering work to adapt effectively to the challenges of the present may be to redefine engineering work in terms of both problem solving and problem definition. (p. 590)

Downey (2005) suggested that one way that engineering educators can help students is by remembering that engineering problem solving starts with a definition. Adding to his argument, it could be more real to say that this team (and engineers in general) *defined* a problem rather than solved it. If the dogs return to campus, then can we really say that the team *solved* the problem? Therefore, the team first *constructed* a problem, then designed a solution to solve that constructed problem. In the process of constructing a problem, they used the engineering design information of the course content and my Western view (e.g., when they said that the dogs are dangerous to human health). How a group of people perceives danger or safety depends on its cultural notion of risk (Douglas & Wildavsky, 1983). Therefore, my intervention in feedback sessions became part of their design process. It was not just Tibetan culture, but also my Western interpretation of notions such as safety and danger that influenced their design.

As will be seen with Team 5, this project made me to reflect on the degree of problem solving or the boundaries of problem solving, meaning that engineers may solve a problem, but only to a certain extent. Moreover, from my reflections, it seems to me that what engineers do is construct problems and then design solutions to solve the problems that they constructed. From the perspective of Buddhism, particularly the "mind-only" or *Yogācāra* school of philosophy, we can argue that any phenomenon in this world is imputed by our human minds (Nagao, 1991). Taking the example of engineers, we can say that when they define a problem, they are imputing their own values and biases onto the problem.

To summarize my reflections about engineering that arose from Team 4's experiences, the process of engineering problem solving is not as easy as identifying a problem and designing a solution. Our solutions might solve problems, but not completely because of human limitations and the reality that technical problems are transformed into human problems when humans are added into the problem definition. In the process of constructing problems, engineers impute their values and biases onto them.

6.6 Team 5: The design of a mechanism to ring the school bell

6.6.1 Overview

Team 5 worked on a design to address the problem of the sound intensity of the school bell (see Figure 6.13). Its members argued that the school bell needed a better mechanism to ring it. Table 6.9 shows that the team consisted of five male students. Three of them were age 16 years, one was age 21 years, and one was age 22 years. All were in class 10+1 and born in Tibet.

Table 6.9 Demographics of Team 5

Gender	Age	Class	Birth Place
M	22	10+1	Tibet
M	16	10+1	India
M	16	10+1	Tibet
M	16	10+1	Tibet
M	21	10+1	Tibet

Figure 6.13 The school bell after their design modifications

6.6.2 Design process

The team members interviewed a student, who said the bell's low sound intensity was causing him to arrive late to class. They even argued that the low intensity sound was the impetus for the staff's speeches about "improper time management":

> Much time is wasted by long speech given by the staff due to improper time management, and many late causes by the students. In which the lack of bell sound is the key cause of improper time management.
>
> In our classroom, there is a great fluctuation in time management due to absent of proper sound bell, which leads to different problems between students and staff.

Their claim about the bell sound was not strong. The consequence of allowing them to undertake the project was that they ended up *creating* another problem rather than solving the existing one—at the end, the bell sound intensity was weaker than before. As one of the physics teacher explained to me, the propagation of the sound waves was hindered by the frame that the students built around the bell.

In a feedback session, I asked about the worker who rings the bell, who is an Indian woman. I recommended that they should take her into consideration in the design process; however, it was not clear to me whether they took that initiative. They did ask her to ring the bell *after* they implemented the design. I speculated but did not confirm that factors related to gender difference, ethnic difference, and role boundaries (they were students and she was a worker) led to their decision to exclude her from the design process. My recommendation stemmed from the work of scholars such as Nelson (2011) who argued that some design projects for development have created gender imbalances rather than solving technical problems:

> Several innovations had social effects that reduced the innovation's ability to alleviate poverty. For instance, the manual labor required by treadle pumps created an imbalance in gender relations when women received the task to pump water. The PlayPump, where designers tried to encourage kids to play on merry-go-rounds that simultaneously pumped water, misread cultural realities and installed the concept in inappropriate locations (Freschi, 2010). Efforts to improve cooking technologies transformed household relationships have increased, rather than decreased, the domestic work undertaken by women (Crewe & Harrison, 1998). Observationally, these examples focus principally on gender relations; gender offers but one lens to view social change. (p. 9)

For the sustainability component of their design process, the team members thought about reusing bicycle chain wheels, bicycle gears, and iron rods to design a simple mechanism that can be rotated by human power. They used the welding facilities of VTC and of a welder at the Selakui market. They justified their materials selection in the following way:

> We decided to use iron because it is the only available metal in our school campus. Also we discussed to use the useless cycling spinning wheels [chain wheels]. We thought that all the metals we used were ecofriendly.

I believe that the course content also influenced them to select old iron rods because Week 2's content explained the manufacturing processes to shape metals.

Only one team member gave the final project presentation in the school auditorium. He gave the talk entirely in Tibetan. He used hand movements to express his thoughts, some of which reminded me of a Tibetan debate. This student was active in Tibetan debate practices at the school. At the end of his talk, he described the bell ringer's operations and the distinct features of its design (see Figure 6.14). In addition, he explained that the project helped the team to learn about time management, work distribution, and welding techniques.

Figure 6.14 Their final project presentation

6.6.3 Summary

As shown in Table 6.10, Team 5 was influenced by (a) the ideas that I shared throughout their design process, (b) the course content, (c) help of others at VTC and at the Selakui market, and (d) the way that they presented the project at the school auditorium.

Table 6.10 What Influenced the Design of Team 5?

	Indian society	Tibetan culture	My Western view	Internet	Course content	Books and magazines
Ideas I shared throughout their design process			✓			
Course content: manufacturing processes					✓	
Help of others at VTC and Selakui market	✓	✓				
Way of giving the talk: hand and body gestures similar to a Tibetan debate		✓				

Whereas Team 4 helped me to reflect on the question “can engineers really solve problems?,” this Team helped me reflect on the effects of solving a problem that is not considered to be a problem by the community. What are the consequences of implementing a design to solve a problem that is only in the perception of the engineers? Will this act create more problems rather than solving the one that they perceive? Can engineers solve problems *without* creating more problems?

In summary, in my view, the team (a) constructed a problem, (b) justified solving the constructed problem, and (c) designed a solution to solve the constructed problem.

My view is consistent with social constructivism (Vygotsky, 1978). This theory of learning can be translated to an engineering context in this way: Every phenomenon (such as an engineered technology) is socially constructed through complex processes that are bounded to sociocultural, historical, and national and international political contexts (Lucena & Schneider, 2008; Winner, 1993); therefore, how the engineers design and implement is limited by this context. The engineers might perceive that they have the "freedom" to design whatever they wish, but in reality they are always designing within limits.

6.7 Team 6: The design of a hydropower reading light

6.7.1 Overview

As shown in Table 6.11, the team consisted of three male students and one female student. They were all in class 10+1. Three were born in India and one in Tibet. The team members considered designing a reading light system powered by the gravitational force of a water stream from the rooftop of their residence. The device would be used only during the monsoon season because, as they explained (and as I experienced as well), that northern region of India experiences frequent power outages during the monsoons. Their assumption was that the gravitational force from the water stream would rotate the paddles connected to a bicycle wheel—a concept similar to that of a waterwheel. A belt would connect the bicycle wheel to a small power generator, which in turn would be connected to an electronic circuit and a light bulb (see Figure 6.15).

Table 6.11 Demographics of Team 6

Gender	Age	Class	Birth Place
M	19	10+1	India
M	16	10+1	India
F	20	10+1	Tibet
M	16	10+1	India

Figure 6.15 A system to power a reading light

6.7.2 Design process

This team responded to most of my questions aimed at helping them to consider the connection between the problem and society. The team members argued that health, social, and environmental factors were connected to the problem of insufficient light to study during the monsoon season. For example, when they explained how health is connected to the problem, they talked about stress:

> It gives stress, when there is no [reading] light, because when you are doing homework, all of sudden, the light is gone and you feel like: "Oh! Now I am not able to finish home work." Also it is not comfortable to do any job.

They explained that electrical outages affect the economy, which displays an awareness of how India's economic system as a nation depends on its electricity:

> Yes, there are social problems when there is no light during rainy season. The whole society has to stop dealing with technology when there is no light. No jobs and more unemployment in society.

In other words, when there is no power, people cannot use technology, and consequently the industrialized society stops producing. This in turn causes unemployment because the technologies that support India's national economic system are dependent on electric power. In a causality study between energy consumption and economic growth, Paul and Bhattacharya (2004) found that this relation may have mixed results in India compared to a "developed" country:

> In the short-run, energy, particularly commercial energy acts as an engine of economic growth. It is a very important primary input in the aggregate production function. In the context of a less developed country like India, the substitution of non-commercial energy by commercial energy is likely to be limited in the short-run. But in the long run, with the growth of income and technological progress, it is likely that more and more non-commercial energy will be substituted by commercial energy. (p. 979)

This team's understanding of the causality of energy consumption and economic development was in the context of a workforce dependent on technology, but they universalized it to cover the entire society. Nevertheless, this team successfully reflected on how technology impacts society and vice versa.

The team also connected the problem with environmental pollution, especially because the school depends on a diesel generator to obtain electricity when there is a power outage:

> Yes, this problem affects the environment. When school, society, or company uses a generator to have electricity, it contributes to environmental pollution. Because we have to use petrol to run the generator, so, it produces more carbon [dioxide] in the atmosphere.

The team displayed an understanding of the macro-scale consequences of using a generator. The pollution that it emits will increase the carbon dioxide in the atmosphere, which the team implied in its description is a negative impact in the atmosphere.

Figure 6.16 First exploration of their idea

In the first report, the team members started to explore their design ideas (see Figure 6.16). Their drawing is of a hydropower turbine connected to a diesel generator, which in turn is connected to a power grid. In this phase, the concept was similar to a dam. Although, the report included a description of a wind energy system, this component was not incorporated into the drawing. The following was their drawing description:

> By using hydropower and wind energy, we can solve these problems. We need to construct a windmill and a model of a dam. With the help of rainwater and strong wind [gusts] we can generate electricity. We do not need to worry when there are not strong winds; we can use hydroelectric power in that moment to have light. Also it is ecofriendly and does not pollute.

In the second report, the team members discarded the use of wind energy but retained the hydropower system. I had suggested during the design feedback they should select just one energy source, because I was concerned about their time and resources to complete the model. I also shared with them information about a micro hydro-power system from Practical Action (n.d.) as a reference as they designed the system.

The team members initially considered using the following materials: A bicycle wheel, old disks (CDs), and an electricity generator. The disks (CDs) would be used as blades for the turbine (bicycle wheel). They decided to use cups rather than CDs, because they assumed that the weight of the water that would fall into the cups, plus the force of the gravitational energy, would rotate the wheel and thus the small power generator.

As with Teams 1, 4, and 8, this team was overconfident about their design outcomes. Statements such as “our design will govern the speed of the turbine very accurately” and “the cost of direct electrification wouldn’t be too high since our design can light a single house” were assumptions only and were not backed by evidence.

Because of their level of physics and mathematics knowledge, they could not provide scientific evidence to back their assumptions, although they formulated statements that could be later refuted or supported by mechanical or electrical engineering knowledge.

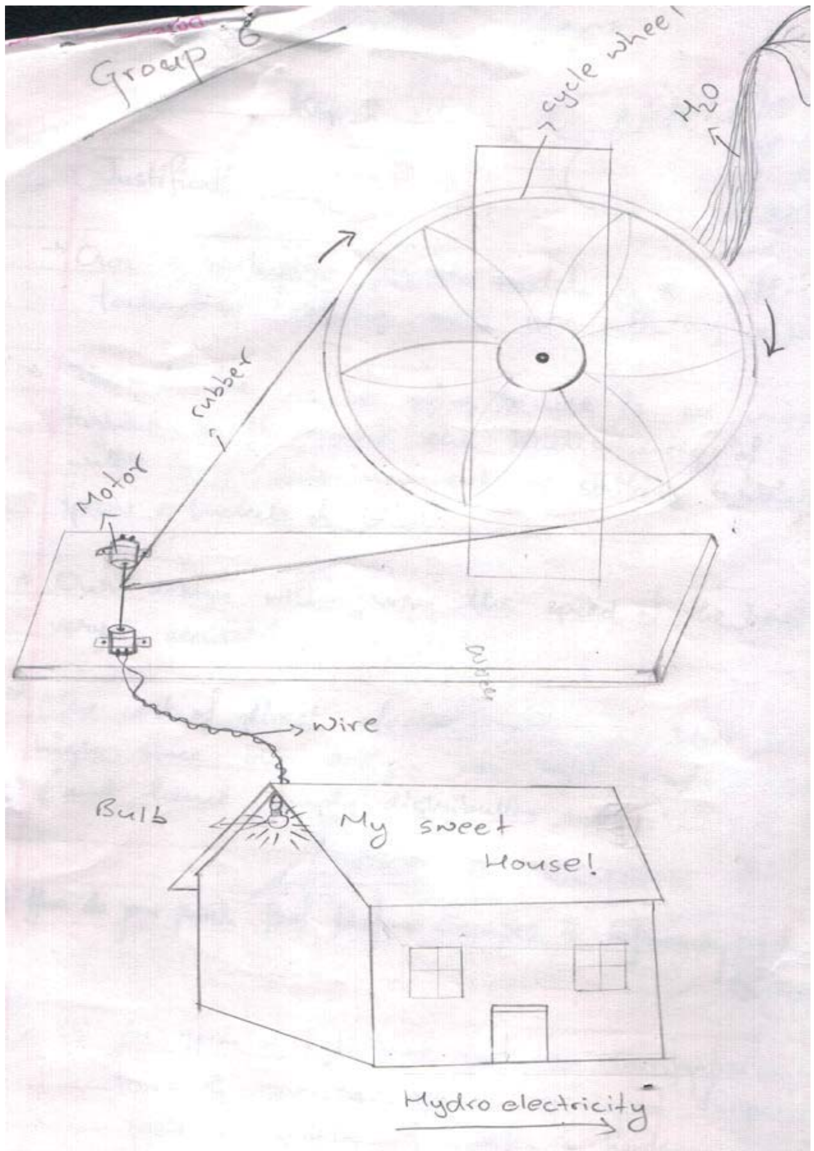


Figure 6.17 Hydropower system design by Team 6

The team members reported that their major difficulty related to finding time to discuss the project. They met two times a week, and they distributed the work according to ability. They confused “requirements of design” with “required materials to make the design," which was typical for most teams. They reported that teachers loaned them some of the wood that they used in their project, which is evidence of community engagement. Interestingly, this was the only team that listed the social studies book of class 9 and class 10 as a reference. The team members searched for information on Wikipedia but did not state under what topics. In their last report, they included a drawing that was exactly the same model that they implemented (see Figure 6.17).

After their final project presentation, I reviewed their design on stage. I was able to move the wheel with my hands and see that the system was effectively powering the reading light. When I turned the wheel forward, a red light turned on, and when I turned it backward a set of white lights turned on. The cups were placed in a position that would turn the wheel forward. If the red light symbolizes the reading light, then they configured their electronic circuit correctly. If not, then, then there was an error in their design (see Figure 6.18).

Figure 6.18 Components of their design

I do not know why the team members decided to include two lights in their implemented design, because their design description mentioned only one reading light. I knew that the team leader had already worked with the small power generator, but I did not receive any indication that somebody else helped the team to set up the circuit, or if the team got the information from the Internet.

6.7.3 Summary

The team members were influenced by the following sources: (a) their knowledge about India's economy, environment, and climate, (b) social science textbooks, (c) micro-hydro power information, (d) Wikipedia Web site, and (e) ideas shared in feedback sessions.

Table 6.12 What Influenced the Design of Team 6?

	Indian society	Tibetan culture	My Western view	Internet	Course content	Books and magazines
Others helped them in finding materials		✓				
Their awareness about India's modern society, the economic system, climate, and the environment	✓					
Social science textbooks of class 9 and 10	✓					✓
Information I shared of the Web site Practical Action					✓	
Wikipedia				✓		
Ideas I shared throughout their design process			✓			

6.8 Team 7: Design of a rat trap

6.8.1 Overview

This team chose the problem of rat proliferation at their residence (girls' hostel). They designed a rat trap with used materials, such as a long plastic bottle and cardboard (see Figure 6.19). The team consisted of three female students in class 10+1. Two were born in Tibet and one in India (see Table 6.13).

Table 6.13 Demographics of Team 7

Gender	Age	Class	Birth Place
F	19	10+1	India
F	19	10+1	Tibet
F	17	10+1	Tibet

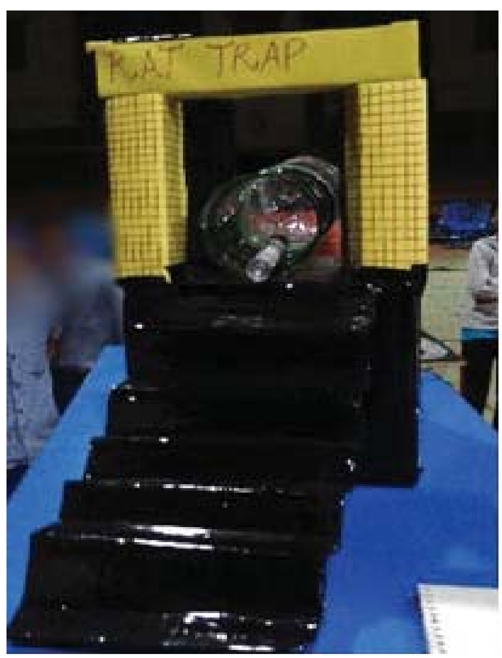


Figure 6.19 Rat trap design by Team 7

6.8.2 Design process

Initially, the members of this team were undecided about which problem to select among the three that they identified: (a) proliferation of rats at the girls' hostel, (b) the need to detect snakes during the monsoon season, and (c) spider webs at the hostel. While they were discussing their ideas for a snake detector, I shared my concern about their safety and lack of resources to make the design. Their concept of a snake detector appeared to be a robotic device that used image recognition, a sensor, and mechanics. It also appeared to be influenced by an example that I included in the design progress report guideline #1 (see Appendix A, section IV: "Examples of Problem Statements") that had to do with designing a barrier to keep toddlers inside of the childcare building to avoid snake bites or other type of accidents. They were very excited about the idea of designing a way to capture snakes, but I asked them to choose other problem because snakes in that region of India are poisonous. Of course, rats can also bite, but they had experience with using cages to catch rats. In addition, I thought that it would be easier to find resources to make a rat trap instead of a snake detector. Considering the time constraints, a rat trap would be more feasible.

During the design process, I highlighted issues that they needed to consider while selecting the problem: Materials, methods to lure the animal, and so on. A team member remembered a traditional design for a rat trap found in Tibet: Two plates separated by a stick.

They made a concept map that identified the different materials that they were thinking of using (see Figure 6-20).

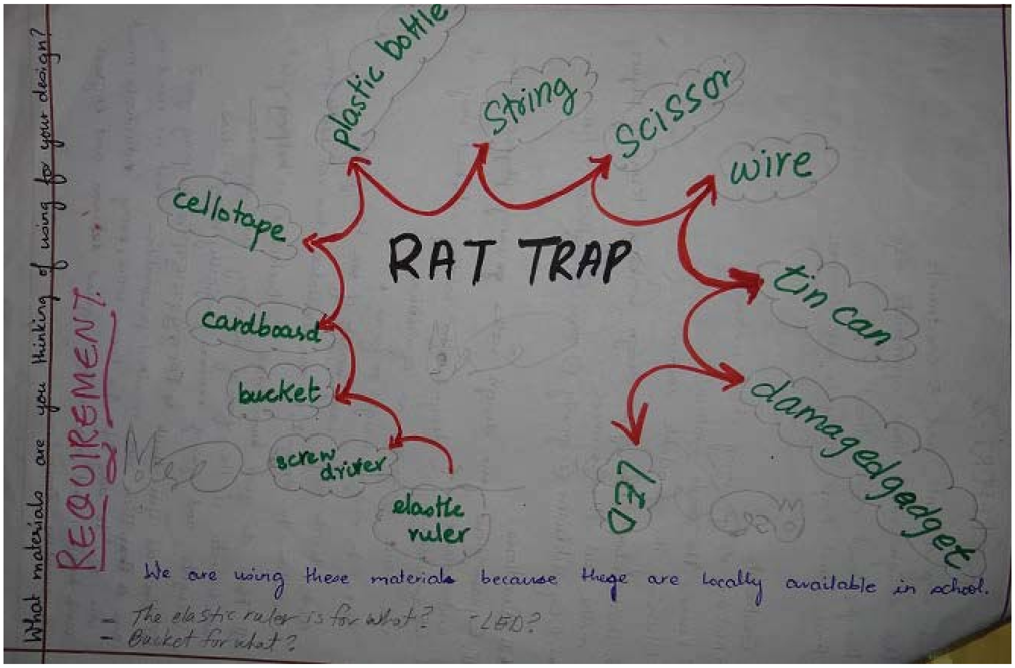


Figure 6.20 Concept map of possible materials

The team members shared several accounts of incidents to justify the significance of this problem. For example, they said that rats have (a) bitten the toe nails of students, (b) made noise in the night, (c) scared girls, (d) jumped on the body of students while they are sleeping, (e) damaged property, and (f) eaten their snacks.

The team members drew two rat trap designs. As with other teams, I shared my feedback via "bubble" comments in the reports (see Figure 6.21). I wanted to determine whether my interpretation of their design aligned with their interpretation. I wrote how I thought the system would work: "1. Mouse gets the biscuit, 2. Mechanism to close the cap, 3. Mechanism to lift the trap…" To remind them of the importance of reusing materials, I highlighted an element of their design: "maybe [reuse a] container." At the top of the page, I summarized my major concern of their design: When the rat falls into the trap and the weights fall down the trap, how will they prevent the rat from being forced from the cup?

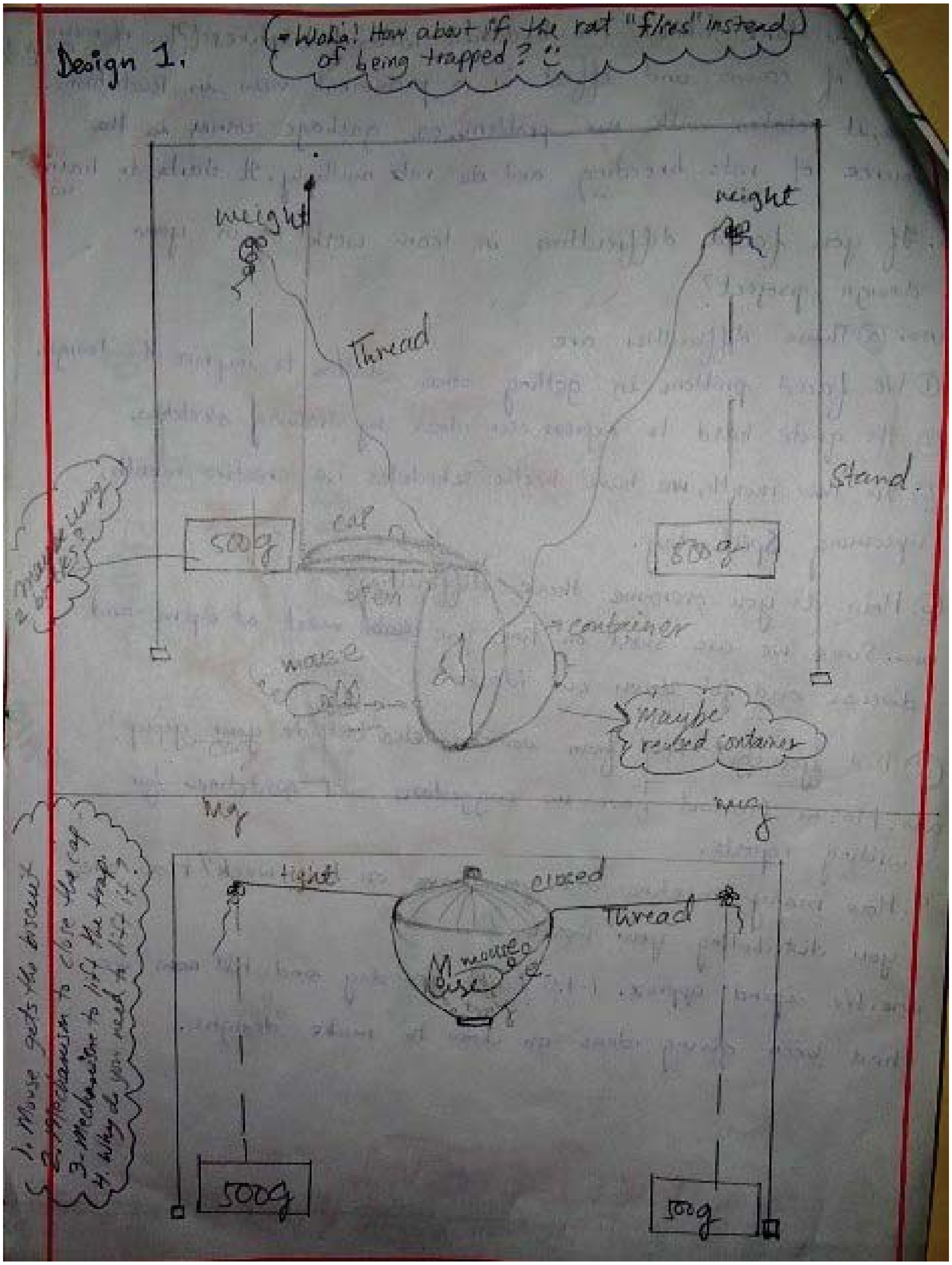


Figure 6.21 Rat trap design 1

The team implemented its second design (see Figure 6.22). Different parts of the drawing are labeled to assist interpretation. As usual, I wrote my feedback in bubbles to aid their reflection.

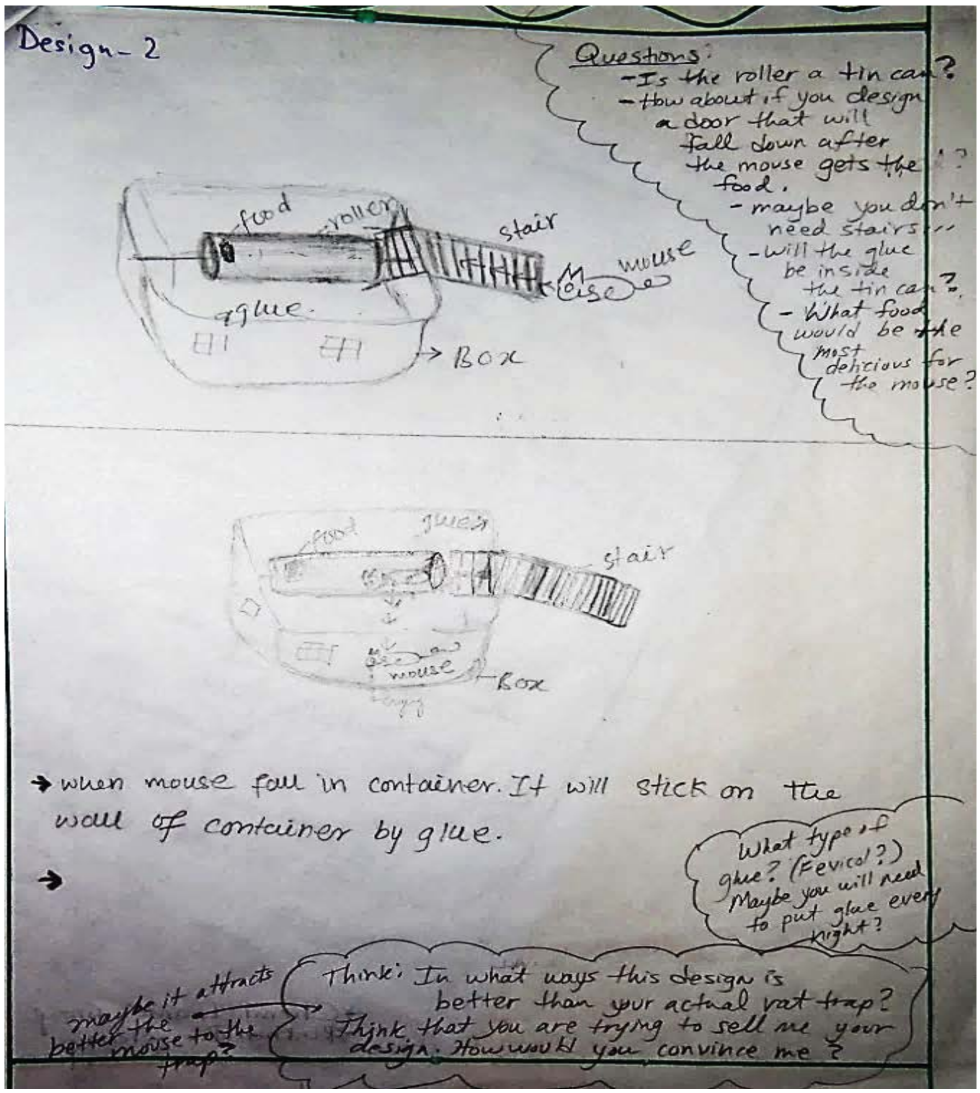


Figure 6.22 Rat trap design 2

For example, I asked: “Is the roller a tin can? How about if you design a [trap] door that will fall down after the mouse gets the food[?] Maybe, you don’t need [the] stairs…” The team retained the stairs but did not implement a door. In this case, the team made their design decisions more independently compared to the other teams.

Regarding Figure 6.22, at the bottom of the page, I wrote: “Think: in what ways this design is better than your actual rat trap. Think that you are trying to sell me your design. How would you convince me?” In the last question, I addressed the values of the consumerist society that provide my background, because I implied that the result of engineering is to sell a marketable product. My concern after the class was: What if the students did not intend to profit from their design? In my analysis, I realized that the question was problematic. My intention was to help the students to reflect, but I did not reflect on the consequences of asking the question. I suggested to them that the correct way of engineering is to capitalize one’s work, which is fine if that aligns with one’s values; however, nothing in these students’ data suggested that wanted to make money with their design.

When I helped them to edit their electronic presentation, I noticed that the team members did not differentiate between design requirements and constraints. This confusion, and that of most of the teams, mirrored my own confusion, because my prior knowledge about requirements and constraints was an incomplete knowledge (Chi, 2008).

The team members acknowledged the following difficulties: (a) to improve the design, (b) to express ideas in drawing, and (c) to balance the demands of other extracurricular activities and my class. They explained that they overcame their difficulties by having brainstorm sessions in the evening. This was the only team to report that it was difficult to express their ideas in drawings; however, I believed that the quality of their drawings was not bad. Because the team consisted of girls, I wondered whether low self-confidence or lack of positive reinforcement from me affected their beliefs that they did not express their ideas well in drawings. They cited the following sources of information: Google Web search (they did not state the Web sites), Wikipedia, Physics textbook of class 10+1, and "ABC class 11 guide book."

The team members presented their final project in Tibetan (except for the presentation in English). They presented all the slides and left the "Physics Concepts" slide for the end to show how their model works. When this all-female team explained how their design works using physics knowledge, students in the audience started to chuckle and laugh, a behavior that was not exhibited during other teams' presentations. See Chapter 4, section 4.6.2 for a discussion of this incident, which I considered to be salient compared to the other teams' presentations.

However, the team's design looked like what was implemented (see Figure 6.23) and reused a long plastic bottle and cardboard.

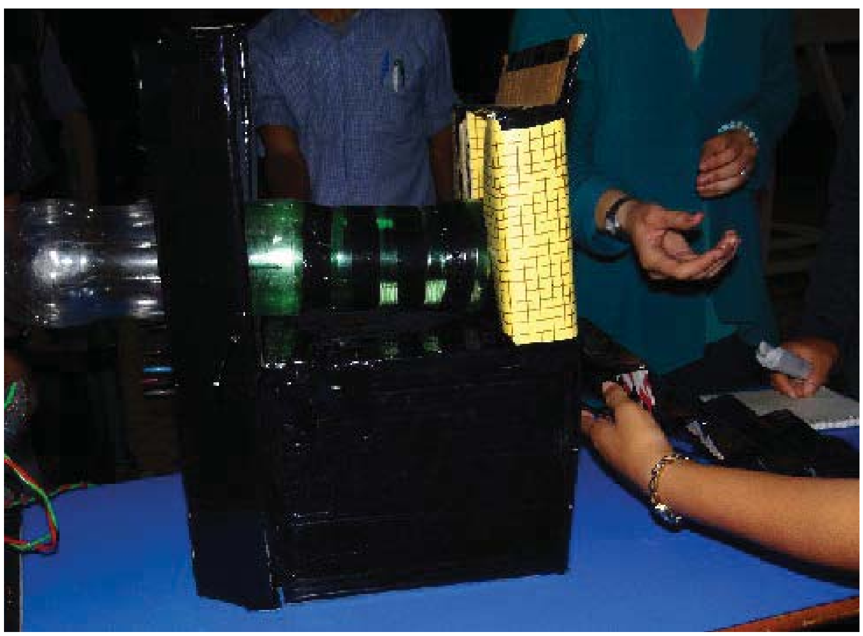


Figure 6.23 Their final model of a rat trap presented at the school auditorium

Bucciarelli (1994) critiqued Western design engineers who focus only on the forms and functions without taking into account the aesthetics of the artifact. In contrast, this team focused not only on the form and function of the design, but also on the aesthetics: it designed a platform and elegant entrance for the rat to get into the trap (the bottle).

6.8.2.1 Design testing

I did not participate in the testing phase, but the following text summarizes the team member's report from 1 or 2 days after the final project presentation. The team member loaned the rat trap to a peer in the boys' hostel and he caught a rat. He placed a potato piece in the bottle opening and a piece of bread in the bottle end, which is not how the trap had been designed to be used. I asked the team member if the peer modified the design because he [the peer] had unsuccessfully attempted to catch a rat before. We speculated that the plastic of the tape was too slippery for the rat to climb onto the "platform" (see Figure 6.23). The team member explained that her team had spent 30 Rupees [79] to buy tape. The rest of the materials (plastic bottle and cardboard) were waste materials found at the school.

Because the bottle was long and the plastic was slippery for the rat feet, the rat became trapped in the bottle. Her explanation provides an example of a naïve (but also legitimate) understanding (Vosniadou, 2009) of materials properties: The material properties of the plastic supported the outcome of trapping a rat at the end of the bottle. The bottle connected to the platform columns, but it rotated downward and thus stood up when the rat became trapped. In this case, the gravitational energy of the rat weight

[79] See footnote 45 for more information about currency conversion details.

caused the bottle to stand up. When the bottle stood up, the rat became trapped in the bottle because of the lack of friction between its feet and the plastic when it attempted to escape. The team determined that the design worked, even though, originally, it was not how they intended it to work.

6.8.3 Summary

Team 7 designed and implemented a rat trap to address the problem of rat proliferation at the girls' hostel and the limited quantities of rat traps. As shown in Table 6.14, the team was influenced by the following sources: (a) ideas that I shared throughout their process, (b) culturally situated design ideas (when a team member remembered how rats were trapped back in her home in Tibet), (c) others helped them to test their rat trap, (d) Web sites, (e) class 10+1 textbooks, and (f) my course content.

Table 6.14 What Influenced the Design of Team 7?

	Indian society	Tibetan culture	My Western view	Internet	Course content	Books and magazines
Ideas I shared throughout their design process			✓			
Culturally situated design ideas that they remembered		✓				
Others helped them in the testing phase		✓				
Google searches and Wikipedia				✓		

Table 6.14 continued

Physics book of class 10+1, unknown book of class 10+1	✓					✓
A problem statement example that I included in the design progress report guideline #1					✓	

6.9 Team 8: The repair of a garbage bin

6.9.1 Overview

This team faced difficulty identifying a problem at the school. It changed project themes twice. At the third attempt, I suggested to repair a garbage bin (see Figure 6.24). The team consisted of three male students and one female student, all of them in class 10+1. Two were age 16 years and two were adults. The three male students were born in Tibet, and the female student was born in India (see Table 6.15).

Table 6.15 Demographics of Team 8

Gender	Age	Class	Birth Place
M	16	10+1	Tibet
M	22	10+1	Tibet
M	18	10+1	Tibet
F	16	10+1	India

Figure 6.24 Photo of the garbage bin ("use me") that they repaired

6.9.2 Design process

In the first report, the team members described a design project that seemed more like a Science Day project than a course project because it did not explicitly provide a solution to a problem at the school site. The team proposed the design of an electronic circuit to ring a bell. It appeared as though Team 8 attempted to assimilate (Svinicki, 2004) the new knowledge of engineering design in its existing mental model of a Science Day project. During this process, the team members realized the need to create a new mental model (Chi, 2008) to accommodate the new information because both terms were not exactly the same.

This team also had difficulty to identifying and investigating a problem at the school; therefore, I helped them by observing the lack of light on the path from the boys' hostel to the school auditorium. This had not been acknowledged as a problem before, because they were used to walking in the dark, but it was the first idea that came up to my mind during the feedback session.

In the second and third report, the team developed the idea that I suggested. The team members decided that using batteries would not be environmentally sound, even more so considering the lack of waste management alternatives in the region. As an alternative to batteries, the team members proposed a design that seizes solar energy. It consisted of light bulbs powered by small solar panels.

Even though the team members assured me of the chance of success of the project in the reports, during the last class they asked whether they could change their project. With little time left before the final presentation (only a weekend), I suggested that they repair one of the school's garbage bins (called a "use me," referring to the literal name written on it). Because of the lack of time and my perception that they were resisting my design project approach that gave them the freedom to identify a problem and figure out a solution, I wrote a separate step-by-step guideline exclusively for this team, 5 days before the final project presentation in the school auditorium (see Appendix G for these special guidelines). They followed these exclusive step-by-step guidelines better than they had the previous progress guidelines, and I think that this is evidence that they truly were struggling to follow a design project approach that did not have strict instructions to follow.

Of all the teams, I faced the most difficulty helping this team during the design progress. I did not want to appear authoritarian; therefore, I did not pressure the team to provide evidence of their progress. Yet at the same time, I worried that the team might not finish the project on time. I noticed a resistance to the design project every time that I met with the team for feedback sessions. It appears that this resistance to the design project stemmed from the team members' aversion to my way of teaching. Alpert (1991) argued that some students resist a course because of the teacher-centric approach of teaching (e.g., lectures):

> I would like to argue that life in high school classrooms often involves a dialectic of resistance and acceptance. Whether resistance or acceptance [in the classroom] will dominate depends on the teaching approach. Student resistance is likely to appear in classrooms where academic subject-matter knowledge is emphasized by the teacher and a recitation style is typical of classroom language interactions. Acceptance and compliance will be dominant in classrooms where the teacher incorporates students' personal knowledge in the instruction and facilitates a responsive style of classroom discourse (Shuy, 1986). (Alpert, 1991, pp. 350-351)

One way to determine whether or not they felt comfortable with the course is by looking at the team members' course feedback responses. Two out of four team members were not satisfied with the project because they wanted to make the electronic bell that they proposed at the beginning of the course. Recall I asked the team to change its project because its original idea did not address a real problem at the school. It appears as though I did not clearly explain (a) why I requested the change in project theme and (b) the difference between a design project and a Science Day project. Two responded to the question "did the course fit your expectations?" in this way:

"Partially. Actually, we wanted to do the electric bell. But due to the sudden consequences, we had to do the dustbin repair project. But anyway we found it quite interesting."

"Partially. The course project was not much helpful as we didn't get much time and our team project itself changed many times."

The team members did not complain about the feedback sessions (or did not want to comment); however, they complained about my culturally responsive teaching approach. They said the following:

"I don't know whether it [engineering] connects with Buddhism or not."

"I think it was enough to connect engineering with Buddhism, but Buddhism is so wide and we can't explain it and said [in] one period. So, [do] more study and explain deeply or more."

"In our society, most students do not have [the] habit to ask questions and [be] frank. So, spend [time] with [each] individual [student]."

"I would delete spoonfeeding[80] [from the course]."

From these responses and the previous observations, I conclude that their resistance to the class activity reflected their rejection of my teaching methods, which is understandable because the classes were like lectures.

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[80] For my interpretation of this response, see footnote in Table 4.12, Chapter 4, section 4.7.7.

Figure 6.25 Helping Team 8 with their presentation

Team 8 listed the materials for its design as requirements of design in the electronic presentation, which reflects its confusion about the difference between a Science Day project and an engineering design project. Because this team changed its project at the end of the course and could not list the design requirements, I tried to list simple ones for them, such as “the metal sheet must cover the square meters of the bottom of the garbage bin,” “the metal sheet must be painted to prevent rust,” and “the metal sheet must be securely attached to the bottom of the garbage bin.” They interpreted “design constraints” as “difficulties that they faced,” which may have been an error in their translation from English to Tibetan. The team members identified the following difficulties: (a) finding a problem at the school, (b) lack of time to work on the project, and (c) lack of resources to make the model. They said that they overcame their difficulties through good teamwork, excellent ideas to succeed, book references about the project theme, and Internet references. The team also sought help from VTC to complete its projects.

During their final project presentation in the school auditorium, the team members spoke in Tibetan and a student next to me translated some of their arguments. As interpreted, the presenter said, “Before, we thought that engineering was a complex thing, but we learned that engineering can be simple” and “Engineering can make life easier” and “[It was a] big problem, but very simple.” I wonder how these statements about engineering match the reality of engineering practice in India. Could this new mental model of engineering design as a simple activity create a frustration when they encounter engineering in the context of India’s colleges? Downey (2005) argued that engineering practice is not equal in every nation and that every nation has constructed its own version of who counts as engineers and how these professionals are qualified. He also pointed out that the commonality of the profession in countries such as the United Kingdom, Germany, France, and America is the “technological change and focus on technical problem solving, locally defined” (p. 585). In the case of America, this is translated as engineers working for the improvement of “the material comfort of the masses through industrial production of low-cost goods” (p. 585).

This observation at the school auditorium helped me to realize that engineering educators should be mindful of the reality of the reconstruction of engineering and the engineering profession among nations in order to present a more authentic version of engineering consistent with the nation’s professional practice. It also lead me to realize that this construction of engineering in politically challenging locations, such as (a) Puerto Rico (a U.S. territory), (b) regions around the world that face ethnic or political disputes between two or more nations (e.g., Crimea), or (c) refugee groups such as Tibetans in India who have what they call a government-in-exile but who depend to a certain extend of the host country (India) and foreign aid might be a “turbulent complexity” between two or more competing discourses about (a) what is engineering, (b) who gets to be considered an engineer, and (c) what should engineers do to develop the nation (and which of the nations).

Therefore, the reconstruction of the engineering profession in these contexts might not be a unified national engineering. I would like to encourage scholars who study global engineering to conduct more research to understand the construction of engineering and the engineering profession in these politically undefined or unstable regions, especially under a post-colonial or post-development perspective, in order to help college-level engineering students understand the complexity of the profession in powerful nations versus nations that suffer the “turbulent waters” of unstable or violent politics.

Returning to the discussion about Team 8, because the students were influenced by my American presentation of engineering, it made sense that they used words such as “engineering can make life easier,” because they reflect the Americanized focus on designs to improve “material comfort” (Downey, 2005).

6.9.3 Summary

As shown in Table 6.16, Team 8 was influenced by the following: (a) ideas I shared with them, (b) their awareness of environmental pollution in India, (c) books and online references, and (d) help of others at VTC and school site.

Table 6.16 What Influenced the Design of Team 8?

	Indian society	Tibetan culture	My Western view	Internet	Course content	Books and magazines
Ideas I shared throughout their design process			✓			
Awareness of the environmental pollution in India	✓					
Books (unknown)						✓
Help of others at VTC and the school		✓				
Web sites (unknown)				✓		

6.10 Summary of chapter 6

Table 6.17 summarizes the sources of influence of each team based on the data collected from their reports, videos of feedback sessions, videos of final project presentations, and my observations. First, every team's design process and teamwork were influenced by three factors: Indian society, Tibetan culture, and my Western view. Teams 8 did not explicitly report that they used the course content, but they referenced Web sites and printed publications. In contrast, Team 5 did not report either Internet or published references. It was unclear to me whether they (a) forgot, (b) did not have access to the Internet, or (c) simply did not obtain sources from the Internet or published references. Team 4 used information from the Internet and was influenced by my course content, but did not reference books. Lastly, in general, they referenced more information from the Internet than from books and magazines.

Table 6.17 Summary of Findings: What Influenced Each Team?

Theme	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8
Indian society	Their awareness of the waste management problem in India.	Design by V. Panchal	Textbooks and magazines from India	Online article in the Times of India	Help at Selakui market	Their awareness about India's modern society, the economic system, climate, and the environment. Social science textbooks of class 9 and 10.	Physics book of class 10+1, unknown book of class 10+1	Awareness of environmental pollution in India
Tibetan culture	Help of others at VTC	Dependent origination. Help from VTC and the school community.	Help of others at the school	Gender-related team-dynamics. Help of others at VTC.	Help of others at VTC	Others helped them in finding materials.	Culturally situated design ideas that they remembered. Others helped them in the testing phase.	Help of others at VTC and school
My Western view	Ideas I shared throughout their design process	Ideas I shared throughout their design process.	Ideas I shared throughout their design process.	Ideas I shared throughout their design process.	Ideas I shared through out their design process.	Ideas I shared throughout their design process.	Ideas I shared throughout their design process.	Ideas I shared throughout design process.

Table 6.17 continued

Theme	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8
Internet	A design of an incinerator that they found on the Internet	Design by V. Panchal	Ideas found on the Internet.	Online article in the Times of India and unknown information taken from Google Web searches.		Wikipedia	Google searches and Wikipedia	Websites
Course content	Design for industry information	Sustain-ability. Dependent origination. Bamboo information.	Engineering design information. A problem statement example in the design progress report guideline #1.	A problem statement example in the design progress report guideline #1	Course content: manu-facturing processes	Information I shared of the Web site Practical Action.	A problem statement example in the design progress report guideline #1	
Books and magazines		Bamboo information.	Textbooks and magazines from India			Social science textbooks of class 9 and 10. Physics book of class 10+1, unknown book of class 10+1	Physics book of class 10+1, unknown book of class 10+1	Books

In addition, I identified particular characteristics pertaining to Tibetan culture that influenced the teams' design process and teamwork (see Table 6.18).

Table 6.18 Characteristics per Team[a]

Theme	1	2	3	4	5	6	7	8
Others helped them at the community: Altruism[b] and community engagement.								
Way that they described the causes and circumstances of the problem (using the logic of dependent origination)[c].								
Minimalizing team conflicts and difficulties[d].								
Gender-related team-dynamics.								
Way of giving the talk: gestures similar to a Tibetan debate.								
A culturally situated design idea that they remembered.								

[a] The shaded columns represent each team's number.
[b] The theme "Altruism" stemmed from Chapter 5.
[c] In the case of Team 7, the theme was discussed in Chapter 5, section 5.2.7. In the case of Team 2, it was discussed in this Chapter, section 6.3.
[d] This theme stemmed from Chapter 5. Refer to sections 5.2.3.1 and 5.2.5.1. For an explanation of "dependent origination," refer to section 4.4.

Most of all teams reported that others in the school community or at the Vocational Training Center (VTC) help them, which evidence community engagement, but it could have been influenced as well by some school community leaders who were enthusiastic about the course. All of the teams presented their projects at the school auditorium in Tibetan because I allowed them to choose between Tibetan, English, or a mix of both languages. However, I required the presentation slides in English because I needed to understand what they were saying.

Unique aspects of certain teams were (a) the way in which they described the problem (e.g., causes, conditions, and effects), (b) minimalizing team conflicts or difficulties, (c) gender-related team dynamics, (d) gestures similar to Tibetan debate, and (e) culturally situated design ideas from their memories in Tibet. I believe that the teams that described their design problems using the "causes, conditions, and effects" structure of logic did so because of the course content: I referenced that type of logic inspired by my limited knowledge of the logic of dependent origination, a Buddhist philosophy concept. In a sense, this finding reflects a mixture of Tibetan culture and my Westernized Tibetan Buddhist knowledge.

In summary, to answer the part of the question "how Tibetan culture influenced design process and teamwork," I identified altruism as the most salient cultural aspects experienced by all teams (finding coming from chapter 5). However, depending on the characteristics of each team (e.g., gender distribution) and the individual characteristics of team members, other traits can be traced to Tibetan culture:

(a) referring to culturally situated design ideas from their family memories in Tibet;
(b) using the logic of dependent origination to describe the problem;
(c) minimalizing team difficulties to value perseverance and to control afflictive emotions that may foster "disharmony";
(d) having gender-related team dynamics and dividing tasks based on gender norms and expectations; and
(e) using gestures from Tibetan debate to give the final project presentation.

Even though these are aspects of Tibetan culture, I do not wish to underestimate the influence of (a) my Western view, (b) my Westernized interpretation of Tibetan Buddhism, (c) the students' awareness of issues of Indian society (the host country), and possibly other influences (e.g., modernist discourses and discourses on progress, development, and technological determinism).

CHAPTER 7. CONCLUSION

This chapter summarizes the major findings of my research study and is divided into four sections: (a) developing and implementing the course, (b) Tibetan culture and Buddhism in students' teamwork and design, (c) limitations of the study, and (d) future directions and final thoughts. The first section answers my first research question, "What are the processes to develop and implement a pre-college culturally responsive introductory engineering course?" and the second section answers the second research question, "How do Tibetan culture and Buddhism influence the engineering design and teamwork of Tibetan students in the pre-college introductory engineering course taught at Tibetan Children's Village School of Selakui?"

My argument in this chapter that concludes this work is that culturally responsive teaching approach has its potentials, but also its limitations, especially for students who have experienced (or are experiencing) colonization by a powerful nation, displacement, or exile. The CR approach is aligned with schools that hold dear the value of honoring the cultural identity of students, and have a mission to strengthen it; however, because of the complex layers experienced by colonized, exiled, or displaced youth (e.g., internal politics, acculturation, impact of what is considered to be "modern," child development, possible psychological effects, transition to adulthood, generational differences, and so on), *some students may still resist this teaching approach*. The approach could be even more challenging to implement with language or ethnic identity boundaries, such as in my study's case. Moreover, even if we share the same cultural or racial identity of our students, we may still find students who will resist to the teaching approach. I will expand more on these points throughout this chapter because others developing or experiencing courses using this approach could experience these challenges.

7.1 Developing and implementing the course

During the process of developing the course, it was beneficial to learn the insights of local teachers who were the real experts on teaching Tibetan youth. For example, a teacher told me that I needed to directly tell the students (a) how the information in each of the lessons may help them and (b) how what they were doing throughout the project was similar to the work of engineers. Based on these suggestions, I added slides to my presentations in an effort to answer the questions and, during the design process, I tried to relate what the students were doing with the work of engineers. While developing the course content, I also familiarized myself with the Tibetan communities outside of the school and took photos of objects and places that could be potentially familiar to the students—for example, structural elements of buildings, machinery, and daily activities in the school that I connected to abstract engineering-related concepts—to incorporate into presentations and to motivate reflection about engineering and society.

Regarding the culturally responsive content, I determined that a design project that connected with the school community was aligned to the value of altruism ("others before self') of the school community and Tibetan culture in general. Some teachers, staff, and personnel at the VTC Center engaged with the students and helped them throughout their projects. The reflective questions to help students think on how the communication skills of the Way of the *Bodhisattva* were relevant in their design and teamwork were responded by them from their perspective as layperson Buddhists. From my observations and their responses, many students thought that associating Buddhist philosophical concepts like dependent origination, sustainability, and the product lifecycle made sense while others did not understand the association. It could have influenced the languages barriers between us.

The students accepted culturally relevant content that connected with their ways of living in their school, Tibetan communities, and surroundings. According to the students' course feedback, they were able to associate abstract concepts with their familiar settings. In addition, they appreciated that I brought to the class information relevant to technology and society in India, the engineers' work in industry, and projects that show engineers helping in poverty alleviation.

With respect to my teaching methods, I noticed that it was difficult for students to respond questions in the classroom about the impact of technology in society, and vice versa. Perhaps this was because of language barriers; however, I noticed that they felt more comfortable sharing their thoughts with me as the days passed. By the end of the course, they were more engaged in class and responding to questions.

Regarding students' expectations, some students stated in the course feedback that they thought I was going to teach more about computers. This confusion may have arisen during the summer, when I volunteered to give brief computer science tutorials, which were unsuccessful because of our expectations. I thought that "tutorials" meant *individualized* tutoring, as I know it in the United States. However, when I went to the classroom, the students were all sitting as if I was going to teach a class. They needed help in computer science topics that I learned a long time ago and was not able to recall in a way that would assist the students. In addition, I experienced feelings of insecurity and anxiety that I would not perform as expected. From their side, they might have assumed that I came from a more "developed" society and education system, and because I presented myself as a person from a United States territory with a degree in computer science, they might have thought that I was an expert in all of the topics that they needed to understand. Because of their high expectations of a Western teacher with a computer science degree —part of their Occidentalism (Carrier, 1992)—my style of teaching, my quiet voice and accent, and my inability to help them learn computer science, I failed to meet their expectations during the tutoring sessions – this may explain why attendance at subsequent tutoring sessions was nil.

Others can extrapolate on these findings in the following ways. First, I recommend the implementation of content that connects to (a) students' familiar ways of living in the host country and home country, (b) multicultural content, (c) engineers working in industry settings, and (d) engineering projects to help alleviate poverty or suffering. Second, I recommend implementation of similar interventions through which students can experience a design project that is similar to a first-year engineering project and that is inclusive of the value of altruism that is important in most cultures. Third, each school and group of students may have other priorities (e.g., required coursework) and needs (e.g., the need to pass engineering schools entrance examinations) that should be taken into consideration with designing a course. In some school contexts, the students may consider it to be more helpful if the Western teacher provides exam coaching to pass engineering entrance exams to improve their chances to obtain college admission or certain scholarships. The teacher should first identify the students' priorities before developing and implementing a course in such school contexts. Fourth, in the same way that religions differ in their interpretations and experiences throughout the world, traditional Buddhists in Asian societies and Western Buddhists have differences in the ways that they practice, understand, and interpret Buddhism based on each practitioner's backgrounds and identities. Finally, one's spirituality is deeply mediated by one's identities (e.g., gender, ethnicity, and so on) and one's personal experiences; therefore, these additional layers affect the ways that students interpret a religion, as compared to a Westerner from a different sociocultural background(s). A teacher must acknowledge these realities to be both culturally responsive and socially just. I was not fully aware of the contrast between the ways that Buddhist laypersons in the "East" and the "West" interpret and practice Buddhism until I had the opportunity to live and conduct research in Tibetan communities in exile in India with predominantly laypersons as my subjects of study.

As a final thought for this section, I recommend that all Westerner teachers of culturally responsive education, who also wish to couple a religion with the teaching approach, should experience living or working with the community before teaching in the community, in order to challenge possible Orientalist (Said, 1994) presumptions about the "other(s)."

7.2 Tibetan culture and Buddhism in students' teamwork and design

Tibetan culture and Buddhism indeed influenced the students' teamwork and design process; however, I identified that each group had particular characteristics that were also influenced by Tibetan culture and Buddhism. In general, I identified that all of them obtained help from the school community in one way or another, evidence of community engagement in the project and their cultural value of altruism.

Because I identified that each team had both general cultural aspects and particular characteristics that can be connected to Tibetan culture and Buddhism, I created Table 7.1 to summarize the most salient characteristics of each team. This is a compilation of the summaries found at the end of Chapters 5 and 6.

Table 7.1 Summary of Findings per Team

	Summary of Findings
Team 1	These team members reflected explicitly on generosity, ethics, patience, and wisdom. They reflected explicitly on perseverance. Concentration was connected in a general way. They reflected on interdependence, *karma*, and equanimity. Phenomena that influenced their design: Ideas they took from the Internet, awareness of waste management problem, the course content & my view, and help of others at VTC.

Table 7.1 continued

Team 2	These team members felt resiliency after they experienced team conflicts and difficulties in their design process because they thought about the reality of *samsara* and impermanence. They explicitly reflected on how generosity, patience, perseverance, and concentration helped them. Ethics and wisdom were implicit. They reflected on *karma,* impermanence, and rebirth. They used the concept of dependent origination to understand the possible causes and conditions of the problem. Phenomena that influenced their designs: the course content & my view, a cart design found on the Internet, a book reference, and help from VTC and others.
Team 3	They explicitly connected to ethics and concentration. Wisdom, generosity, perseverance, and patience were implicit when they talked about their team relationship. They minimalized their team's conflicts. They reflected on interdependence, *karma*, and rebirth in their teamwork and design experiences. Phenomena that influenced their design: the course content & my view, ideas found on the Internet, library references, and help of others.
Team 4	These team members explicitly reflected on all six virtues except for generosity. Generosity was implicit in the humane treatment of dogs. They reflected on *karma* and interdependence. They expressed a tension between their collective beliefs and individual views. They divided work based on gender roles: boys worked to make the design and girls worked to write the reports. They acknowledged that they had team conflicts which I attributed to cultural gender norms and cultural gender dynamics. Phenomena that influenced their design: my view and the course content, information found on the Internet, and help of others.
Team 5	These team members explicitly reflected on generosity, perseverance, patience, and wisdom. Concentration and ethics were implicit in the way that they attempted to minimalize the team's difficulties to focus on hard effort and their successes. One of the team members presented the final project using hand gestures that resembled a Tibetan debate (because the student was active in Tibetan debate classes at the school). Phenomena that influenced their design: my view and the course content, and help of others at VTC and Selakui market.

Table 7.1 continued

Team 6	These team members reflected explicitly on ethics, patience, concentration, and wisdom. Generosity and perseverance were implicit in the way that they described the interdependence of teamwork They reflected on *karma* and rebirth. They expressed confidence that their ideas were going to be valid even though others did not take their ideas seriously. Phenomena that influenced their design: my view and course content, information found on the Internet, textbooks, and their awareness about India's society, climate, and the environment.
Team 7	They mentioned *in general* that the six virtues helped them to work hard, control emotions, and innovate. They implicitly connected with interdependence. They used a logic similar to dependent origination when they explained the causes and conditions of their problem. In their design process, one of the team members remembered a culturally situated design of a rat trap that she saw in Tibet. They connected their problem with the notion of *karma*. Phenomena that influenced their design: my ideas and the course content, information from the Internet, textbooks, and others at the school.
Team 8	These team members expressed a resistance toward the design project. They generally said that the six virtues helped them to counteract the laziness, boredom, and anger that they felt throughout the course and design project. Perhaps these feelings came from their resistance to my teaching approach that tried to connect something perceived as "traditional" (Buddhism and their culture) with something "modern" (engineering). Phenomena that influenced their design: my view, awareness of India's environmental problems, textbooks, information from the Internet, and help of others at VTC.

In addition to Tibetan culture and Buddhism, other sources of influence and knowledge during their design process included my Western view, information from the Internet and school library, textbooks authorized by India's CBSE curriculum standards, and knowledge pertaining to issues of India (where they live). All of the teams certainly were influenced by my Western view on "problems" at the school site that I observed. These problems came from my personal Western education and background. For example, I observed that there should be ways to help ease the community service work of children, which stemmed from my Western view of children's "proper" level of work. However, if viewed from a more traditional Tibetan societal perspective, it is normal for children to do what could be considered in some Western contexts as "hard work." Thus, this is an example of how design is not an "isolated" process: it is subject to the influence of many cultural views, beliefs, and ideologies.

7.3 Limitations of the study

The major limitation is that I conducted a doctoral research fieldwork in Tibetan communities in Uttarakhand and Himachal Pradesh without knowing either Tibetan or Hindi languages. My fieldnotes were in English and sometimes in a mix of English and Spanish. My students' first language was Tibetan. I consider my thinking process to take place in "Spanglish" (a mix of English and Spanish) because my mother tongue is Spanish, and in my early childhood I was exposed to a lot of references and media in English. The students' progress reports, questionnaires, and interactions with me were through English. I knew some Tibetan words, but I was not proficient enough in it to conduct interviews or teach in the language. When I needed minor translations, I relied on school administrators or my teacher assistant, which limited my data collection and analysis. I did not consider the language switching and interactions to be part of my analysis, although I believe that they mattered; as a result, I am listing this gap as a limitation of my study. I encourage a linguistics or communications scholar to bring his or her perspective to the phenomena of study.

Another limitation is that I am not Tibetan, which has influenced fieldwork and the way that I interpreted the data. The students considered me to be a Westerner, although perhaps, as some participants related, a Westerner with a “different character.” I told the students that I was born and raised in Puerto Rico, a territory of the United States, but that my home is Indiana. Therefore my sociocultural identities played a role in the study’s limitations: I am a “Western Buddhist convert;” a “Puerto Rican” from a family of former peasants (or *jíbaros* as they are called in Puerto Rico) until the 1960s when they moved to the capital to begin their postsecondary studies; I was raised in the capital of Puerto Rico; and I believe that I am also an American because I developed this identity in my early childhood and because of my experiences in the continental United States (I describe my sociocultural background with more details in section 3.3). Therefore my sociocultural backgrounds, my postcolonial view, my initial Orientalist (Said, 1994) assumption about the universality of Buddhist interpretations and practices, and my students’ Occidentalism (Carrier, 1992) were limitations in the data collection and analysis. This is neither the only way of interpreting my study nor somehow the most “truthful” one; it is only my way of interpreting it based on my “theoretical lenses” and how I make sense of them.

I wonder to what extent the pressure that some students might have felt to perform well in front of a Western teacher might have impacted some of their responses and “biased” my analyses. It certainly can be true that many students were honest in their reflections about how they believed that Tibetan culture and Buddhism influenced their design projects and teamwork, but I cannot discard the notion that some of them might have felt a social, peer, or cultural pressure to write reflections that were consonant to the discourses of cultural authenticity in Tibetan society in exile. This is understandable because students are in a sense at the bottom of school organizations and are in a more vulnerable position in the society. However, from the data analysis and course feedback, I can say that the students generally seemed honest. When they did not agree with me, they told me so in their reports or course feedback. It is impossible for me to say whether their responses were really reflections or their internalized beliefs about their culture and Buddhism. Therefore, these are potential biases in my research.

Finally, it was challenging to balance the need to conduct the research with my responsibility to effectively teach the course and help eight student teams during their design projects by means of feedback sessions. I believe that my teaching was the part of the project in which I had most difficulty. Sometimes I needed to be prepared not only to teach the class but also for the feedback sessions. Thus, I believe that I ended up paying more attention to preparing for the feedback sessions rather than the teaching: A mirror of the real tension among my duty as a doctoral researcher, responsibility to support the students' design experiences, and teaching all at the same time. These challenges also limited my research data collection.

7.4 Future directions and final thoughts

As I discussed in Chapter 5, more research is needed on (a) the effect of Tibetan cultural background in Tibetan engineers, and (b) the intersection of region of upbringing and generational differences in cultural identity development among Tibetans in exile in India.

Whalen-Bridge (2011) discussed about how the different discourses on modernity (what he calls "multiple modernities") impact the politics and education of Tibetans in exile in India. Building on his perspective, I started exploring this subject of "multiple modernities" in science and engineering education in Tibetan society in exile in section 4.5. I believe that more research should be conducted on the topic because these students seem to be between the "waters" of different modernist discourses: Indian society, Tibetan society in exile, Western-European, Western-American, Chinese, and possibly many more. My assumption is that these discourses could be shaping their perceptions of engineering and sustainability, probably through a lens of development and technological determinism, but one that could be in tension with Western-European influenced environmentalism in Tibetan society in exile (refer to Barnett, 2001, p. 276).

Another of my research ideas is more relevant to those who study nationalisms and the construction of a national culture and identity. It is the study of the similarities between the discourses and ways that the Tibetan government-in-exile constructs, reconstructs, and authenticates the Tibetan national culture and identity in exile, and how these processes are similar to (a) Puerto Rican nationalism and (b) the construction (and reconstruction) of a Puerto Rican national identity on the island by Puerto Rican political leaders and the Puerto Rican government. This idea came to me after my observations living in Tibetan society in exile in India; however, because this study topic is out of the scope of my own doctoral research, I wanted to note it here for other scholars to explore because I believe that it is worthy of attention, particularly from a postcolonial or postnationalist perspective.

Yet another research idea can stem from the interview transcripts data of the four Tibetan engineers that I interviewed. In their interviews, I also asked them about their transition from high school to engineering colleges. Perhaps this data can be analyzed alongside with the data of other minority engineering students in India or be compared with the transitions of other minority engineering students in the United States.

I question what would be appropriate modifications to teach the course in other science-focused Tibetan schools such as TCV of Bylakuppe located in Karnataka, India. My assumption is that the course will need to be modified to suit in that different Indian region, their resources, and facilities. Therefore, if they think that the course should be taught in TCV of Bylakuppe as well, teachers should adapt it to their particular context and situation.

In the case of implementing a course such as the one I proposed in the United States, I ask what might be the adaptations needed to teach a similar course in a school context with a higher rate of immigrant children, who may have come from rural contexts, and who need a culturally sensitive and inclusive way to transition to American schools? I also question the universality of culturally responsive engineering education in American contexts: Can this educational approach be useful for all students of color? What about immigrants? What about developing and implementing a similar approach in a First Nations or Native American reservation? From my observations in my study and in previous interventions (e.g., a Mongolian children's summer camp in the summer of 2011), I believe that, for adolescents who have learned through contemporary education and their parents the perspective of modernism and scientific positivism (because that is the dominant and authoritative discourse in contemporary education), a culturally responsive engineering education can be seen awkward. However, for some children who still have direct contact with family practices that are considered traditional from their cultural heritage, or who have an admiration for that way of living (or cultural background), or who lived part of their lives in such environments (and who had a relatively positive experience), the approach of teaching can be a method to help them feel welcomed and included in engineering education. It can incorporate an inspirational component as well, as my students expressed their views in the course feedback (refer to section 4.7

As I discussed in Chapter 2, the main drawback of culturally responsive education is that it is difficult to implement in modern education settings because of the curriculum standards and assessment methods (Sleeter, 2012). In addition, it has been argued that it takes more time to develop course content and train the teachers (Castagno & Brayboy, 2008). Morrison, Robbins and Rose (2008) proposed these limitations of the approach because the majority of the published research was conducted in ethnically homogeneous classrooms.

Based on my reflections, literature review, and data analysis, I also ask the following questions: (a) If a teacher is not part of the students' ethnic group, then how do we know that he or she is not constructing a new culture through his or her culturally responsive content? (b) In the case of students who fled forms of violence and political conflicts in their homeland, and who are suffering the psychological effects of it, what content should and should not be brought to the classroom? (c) How can we be sure that our content is not propagating stereotypes of our students that may lead to more injustices? and (d) How can we ensure that we are not focusing on certain cultures more than others, in the case of teaching in heterogeneous classrooms (e.g., mixed ethnic groups)? My reflections echo Eglash, Gilbert, Taylor, and Geiger (2013) who recommended the following to culturally responsive teachers:

> Give children the flexibility to explore other cultures and identities. Most of the literature on Culturally Responsive Education focuses on self-identity: the need for elements of the child's own culture to be integrated into the curriculum. But many children are 'hybrids' to begin with, and even if they are not as individuals, most classrooms are collectively. (p. 652)

To sum this point up, although this approach to teaching is better than being a "culturally insensitive" teacher, teachers should question the universality of the approach: Can the approach be implemented in other non-American contexts (as I did)? What about immigrant students and first generation Americans? What could be the challenges or successes of implementing this approach in cultural groups in the United States that have experienced (or are still experiencing) oppression (e.g., Native American tribes) or ethnic groups who are divided because of a history of colonization(s), migration(s), and unstable politics (e.g., Puerto Ricans)? In the case of representing the culture of an ethnic group, which version of their culture are we going to represent? If we develop and implement a course like this in an American school with a higher percentage of immigrant students, in the case of immigrant students who have experienced accumulative violence and oppression in their homeland or who had an accumulation of life-threatening experiences in their homeland (e.g., gender-based violence, war, and so on), bringing content that can indirectly make them remember these experiences may trigger stress-related neurobiological responses that can obstruct learning (Rainnie & Ressler, 2009; Scheiner, 2013). From a special education perspective, this is particularly relevant in the case of students who are suffering from post-traumatic stress disorder (PTSD) as an effect of their refugee experiences or different forms of accumulative forms of violence experienced in their homeland (Joyce, Earnest, de Mori, & Silvagni, 2010; Kaplan, 2009; Servan-Schreiber, Le Lin, & Birmaher, 1998).

I recommend that teachers be mindful of what type of sociocultural content they bring to the class to help students understand academic abstractions in their past or present sociocultural realities. In some circumstances, a culturally responsive approach to teaching could be more effective in *individualized* teaching and mentoring than teaching to a group of students, because we then may draw examples from *individual* sociocultural realities that we as teachers learn from the student that are safe to use as examples to help the student understand abstract STEM-related concepts.

In addition, teachers should take into account the reality of global mobilizations of cultural groups around the world. Even more, a student from a certain nation (or whose parents came from that nation) may not have the same view, experience, and interpretation of his or her own culture as the people of power in his or her own nation see it. For example, the cultural heritage group to which I belong (Puerto Rican) is more diverse than what some people think that they (and we) are. Puerto Ricans in the diaspora and in the island may have some shared phrases, gestures, ways of making meaning to things, cuisine, dances, music, and so on; but *each* individual Puerto Rican has a "kaleidoscope" of individual identities and experiences that make us as a group more diverse and multicultural than what we (and you) think that we (and they) are. Some of us believe that we are only Puerto Ricans while others acknowledge the reality of Americanization, therefore acknowledging that they are also Americans; others have assimilated into the American mainstream; yet still others may identify themselves in an intersection of multiple cultural, ethnic, or national identities (e.g., in the case of those born and raised in mixed families). Therefore, a culturally responsive engineering educator teaching to ethnic minority students who may belong to one or more cultural groups (e.g., some international students, immigrant students, Puerto Ricans in the diaspora, and some Indigenous students), should be mindful that some "culturally responsive content" can be perceived "awkward" depending on the content brought to class, the students' political views, individual identities coupled with his or her experiences of his or her culture (and sometimes even religion), multiple modernities; and the techno-centric, development, and modernization discourses which are the dominant discourses in contemporary science and engineering education.

I described some other concerns throughout the chapters: What if the students' interpretations and experiences of culture and religion (in my project's case is Tibetan culture and Tibetan Buddhism) are different from mine? In that case, and from a postcolonial perspective, our intervention with culturally responsive teaching or content may be seen by some students as another form of colonialism or even Western imperialism, because we are unknowingly representing a culture and religion from the perspective of a Westerner (and in my case as a "Puerto Rican American Western Tibetan Buddhist convert"). This can be translated into other contexts as well: For example, in the case of some Native American students who, because of their ancestors' experiences of colonialism(s), politics, and even because of diverse religious views in their communities, they might even perceive a non-Indigenous teacher teaching a "culturally relevant" content as awkward, offensive, or not authentic to their view.

If a similar culturally responsive engineering educational approach is implemented in other contexts where immigrant or Indigenous students will attend, then I believe that a culturally responsive engineering education can be a socially just and caring approach of teaching, if the teachers are mindful of (a) the context of the school (e.g., values, missions, curriculum standard followed, and things in the surroundings that can be referenced in teachings to help students understand academic abstractions), (b) sociocultural background of the students, and (c) one's possible Orientalism (Said, 1994), all of which need to be examined and questioned.

As a closing, I can summarize my most important lessons from my doctoral research study as follows:

- The fact that one shares an identity with one's students does not mean that one's students will see us part of their group. Ethnic and national identities in some cases may create stronger boundaries between the teacher and students, even if they both share an identity (e.g., gender, religion, and so on).
- Teachers have to question their expectations about the technical capacity of individuals in "developing" nations. Those expectations might not be aligned to the reality that some individuals in "developing" nations might be ahead of us or as equal as us in technical knowledge level.
- Some students may resist culturally responsive approaches of teaching even if one is teaching in a school that values the cultural identity of their students and that has the mission to develop and strengthen this identity. This resistance could be even stronger in students who have experienced the effects of colonialism, exile, or displacement.

BIBLIOGRAPHY

BIBLIOGRAPHY

Alekseevich, S. A., Alexandrovich, S. A., Ivanovich, P. V., & Stanislavovich, P. S. (2012). Engineering education technique based on professional activity imitation. *Procedia - Social and Behavioral Sciences*, *55*, 707–709. doi:10.1016/j.sbspro.2012.09.555

Allada, V. (2006). Enhancing engineering education using thematic case-based learning. *International Journal of Engineering Education*, *22*(2), 236–246.

Alpert, B. (1991). Students' resistance in the classroom. *Anthropology & Education Quarterly*, *22*(4), 350–366. doi:10.1525/aeq.1991.22.4.05x1193w

Amatea, E. S., Cholewa, B., & Mixon, K. A. (2012). Influencing preservice teachers' attitudes about working with low-income and/or ethnic minority families. *Urban Education*, *47*(4), 801–834. doi:10.1177/0042085912436846

Ambe, E. B. (2006). Fostering multicultural appreciation in pre-service teachers through multicultural curricular transformation. *Teaching and Teacher Education*, *22*(6), 690–699. doi:10.1016/j.tate.2006.03.005

Anand, D. (2000). (Re)imagining nationalism: Identity and representation in the Tibetan diaspora of South Asia. *Contemporary South Asia*, *9*(3), 271–287. doi:10.1080/713658756

Anand, D. (2003). A contemporary story of "diaspora": The Tibetan version. *Diaspora: A Journal of Transnational Studies*, *12*(2), 211–229. doi:10.1353/dsp.2011.0063

Anand, D. (2007). *Geopolitical exotica: Tibet in western imagination*. Minneapolis, MN: University of Minnesota Press. Aurandt, J., & Butler, E. C. (2011). Sustainability education: Approaches for incorporating sustainability into the undergraduate curriculum. *Journal of Professional Issues in Engineering Education and Practice*, *137*(2), 102–106. doi:10.1061/(ASCE)EI.1943-5541.0000049

Baillie, C. (Ed.). (2004). *Green composites*. Cambridge, UK: Woodhead Publishing.

Baillie, C., & Catalano, G. (2009). Engineering and society: Working towards social justice, part I: Engineering and society. *Synthesis Lectures on Engineers, Technology, and Society*, *4*(1), 1–114. doi:10.2200/S00136ED1V01Y200905ETS008

Baillie, C., Feinblatt, E., Thamae, T., & Berrington, E. (2010). *Needs and feasibility: A guide for engineers in community projects—The case of waste for life*. San Rafael, CA: Morgan & Claypool Publishers. doi:10.2200/S00249ED1V01Y201001ETS013

Baillie, C., Ko, E., Newstetter, W., & Radcliffe, D. F. (2011). Advancing diverse and inclusive engineering education practices through interdisciplinary research and scholarship. *Journal of Engineering Education*, *100*(1), 6–13. doi:10.1002/j.2168-9830.2011.tb00002.x

Banks, J. A. (Ed.). (2003). *Handbook of research on multicultural education*. San Francisco, CA: Jossey-Bass.

Barnett, R. (2001). "Violated specialness": Western political representations of Tibet. In T. Dodin & H. Räther (Eds.), *Imagining Tibet: Perceptions, projections, & fantasies* (pp. 269–316). Boston, MA: Wisdom Publications.

Bartolome, L. I. (1994). Beyond the methods fetish: Toward a humanizing pedagogy. *Harvard Educational Review*, *64*(2), 173.

Bentz, A.-S. (2012). Being a Tibetan refugee in India. *Refugee Survey Quarterly*, *31*(1), 80–107. doi:10.1093/rsq/hdr016

Berndt, A., & Paterson, C. (2010, April). *Global engineering, humanitarian case studies, and pedagogies of transformation*. Paper presented at the 2010 IEEE Transforming Engineering Education: Creating Interdisciplinary Skills for Complex Global Environments, Dublin, Ireland. doi:10.1109/TEE.2010.5508956

Bhatia, S. K., & Smith, J. L. (2008). Bridging the gap between engineering and the global world: A case study of the coconut (coir) fiber industry in Kerala, India. *Synthesis Lectures on Engineers, Technology and Society*, *3*(1), 1–58. doi:10.2200/S00112ED1V01Y200804ETS006

Birks, M., & Mills, J. (2011). *Grounded theory: A practical guide*. Los Angeles, CA: Sage.

Bower, G. H. (1992). How might emotions affect learning? In S.-A. Christianson (Ed.), *The handbook of emotion and memory: Research and theory*, (3–31). Hillsdale, NJ: Lawrence Erlbaum.

Breault, R. A. (1995). Preparing preservice teachers for culturally diverse classrooms. *The Educational Forum*, *59*(3), 265–275. doi:10.1080/00131729509336402

Brodie, K. (1989). Learning mathematics in a second language. *Educational Review*, *41*(1), 39–53. doi:10.1080/0013191890410105

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Cambridge, MA: Harvard University Press.

Bucciarelli, L. L. (1994). *Designing engineers*. Cambridge, MA: MIT Press.

Buddhist Global Relief. (n.d.). *What we do*. Retrieved from https://buddhistglobalrelief.org/active/whatWeDo.html

Buddhist Peace Fellowship. (2012). *Buddhist Peace Fellowship: Cultivating compassionate action*. Retrieved from http://www.buddhistpeacefellowship.org/

Cardella, M. E., Hoffmann, S. R., Ohland, M. W., & Pawley, A.L. (2010). Sustaining sustainable design through "normalized sustainability" in a first year engineering course. *International Journal for Engineering Education*, *26*(2), 366-377.

Carrier, J. G. (1992). Occidentalism: The world turned upside-down. *American Ethnologist*, *19*(2), 195–212.

Carrier, J. G. (1995). *Occidentalism: Images of the West*. New York: Oxford University Press.

Castagno, A. E., & Brayboy, B. M. J. (2008). Culturally responsive schooling for Indigenous youth: A review of the literature. *Review of Educational Research*, *78*(4), 941–993. doi:10.3102/0034654308323036

Catalano, G. D. (2012). Listening to the quiet voices: Unlocking the heart of engineering grand challenges. *International Journal of Engineering, Social Justice, and Peace*, *1*(2), 152–159. Retrieved from http://library.queensu.ca/ojs/index.php/IJESJP/article/view/4313/4533

Cavallaro, D. (2001). *Critical and cultural theory thematic variations*. New Brunswick, NJ: Athlone Press.

Chi, M. T. H. (2008). Three types of conceptual change: Belief revision, mental model transformation, and categorical shift. In S. Vosniadou (Ed.), *Handbook of research on conceptual change* (pp. 61–82). Hillsdale, NJ: Erlbaum.

Choephel, T. (2011, August 8). At home in exile. *Phayul*. Retrieved from http://www.phayul.com/news/article.aspx?id=29840&t=1

Claris, L., & Riley, D. (2012). Situation critical: Critical theory and critical thinking in engineering education. *Engineering Studies*, *4*(2), 101–120. doi:10.1080/19378629.2011.649920

Clark, P. M. (1998). A Botswana education: Experiences in teaching English as a foreign language. *System*, *26*(1), 77–91. doi:10.1016/S0346-251X(97)00065-1

Cobern, W. W. (1998). Science and a social constructivist view of science education. In W. W. Cobern (Ed.), *Socio-cultural perspectives on science education* (pp. 7–23). Netherlands: Springer. Retrieved from http://link.springer.com/chapter/10.1007/978-94-011-5224-2_2

Coleman, J. W. (2001). *The new Buddhism: The western transformation of an ancient tradition*. New York: Oxford University Press.

Connell, R. W. (2002). *Gender*. Malden, MA: Blackwell Publishers.

Creighton, M. R. (1995). Imaging the other in Japanese advertising campaigns. In J. G. Carrier (Ed.), *Occidentalism: Images of the West* (pp. 135–160). New York: Oxford University Press.

Crowder, E. M. (1996). Gestures at work in sense-making science talk. *Journal of the Learning Sciences*, *5*(3), 173–208. doi:10.1207/s15327809jls0503_2

Cunningham, C. M., Knight, M. T., Carlsen, W. S., & Kelly, G. (2007). Integrating engineering in middle and high school classrooms. *International Journal of Engineering Education*, *23*(1).

Dalai Lama. (1992). *A Buddhist concept of nature*. Retrieved February 21, 2014, from http://www.dalailama.com/messages/environment/buddhist-concept-of-nature

Dalai Lama. (2005). *The world of Tibetan Buddhism: An overview of its philosophy and practice*. Boston, MA: Wisdom Publications.

Davids, T. W. R., & Stede, W. (1993). *Pali-English dictionary*. New Delhi, India: Motilal Banarsidass Publishers. Retrieved from http://books.google.com/books?id=0Guw2CnxiucC

Deleanu, F. (2005). A preliminary study on the meditation and the beginnings of Mahāyāna Buddhism. In P. Williams (Ed.), *Buddhism: The origins and nature of Mahāyāna Buddhism: Vol. III. Some Mahāyāna religious topics* (pp. 26-73). New York: Routledge. Retrieved from http://books.google.com/books?id=LwSRqVKQ46MC

Dessler, A. (2011). *Introduction to modern climate change*. New York: Cambridge University Press.

Dhargyey, N. (2003). *Tibetan tradition of mental development*. Dharamsala, HP, India: Library of Tibetan Works and Archives.

Domínguez, H. (2005). Bilingual students' articulation and gesticulation of mathematical knowledge during problem solving. *Bilingual Research Journal*, *29*(2), 269–293. doi:10.1080/15235882.2005.10162836Douglas, M., & Wildavsky, A. (1983). *Risk and culture: An essay on the selection of technological and environmental dangers*. Oakland, CA: University of California Press.

Downey, G. (2005). Are engineers losing control of technology?: From "problem solving" to "problem definition and solution" in engineering education. *Chemical Engineering Research and Design*, *83*(6), 583–595. doi:10.1205/cherd.05095

Downey, G. L., & Beddoes, K. (2010). What is global engineering education for? The making of international educators, part III. *Synthesis Lectures on Global Engineering*, *1*(1), 1–228. doi:10.2200/S00303ED1V01Y201010GES002

Downey, G. L., Lucena, J. C., Moskal, B. M., Parkhurst, R., Bigley, T., Hays, C., Jesiek, B. K., Kelly, L., Miller, J., Ruff, S., Lehr, J., & Nichols-Belo, A. (2006). The globally competent engineer: Working effectively with people who define problems differently. *Journal of Engineering Education*, *95*(2), 107–122.

Duffy, J., Barington, L., Moeller, W., Barry, C., Kazmer, D., West, C., & Crespo, V. (2008). Service-learning projects in core undergraduate engineering courses. *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, *3*(2). Retrieved from http://library.queensu.ca/ojs/index.php/ijsle/article/view/2103

Durkin, K., & Shire, B. (1991). *Language in mathematical education: Research and practice*. Philadelphia, PA: Open University Press.

Edward, N., & Middleton, J. (2002). The challenge of induction! Introducing engineering students to higher education: A task-oriented approach. *Innovations in Education & Teaching International*, *39*(1), 46–53. doi:10.1080/13558000110102922

Eglash, R. (1997). When math worlds collide: Intention and invention in ethnomathematics. *Science, Technology, & Human Values*, *22*(1), 79–97.

Eglash, R., Gilbert, J. E., Taylor, V., & Geier, S. R. (2013). Culturally responsive computing in urban, after-school contexts two approaches. *Urban Education*, *48*(5), 629–656. doi:10.1177/0042085913499211

Falcone, J., & Wangchuk, T. (2008). "We're not home": Tibetan refugees in India in the twenty-first century. *India Review*, *7*(3), 164–199. doi:10.1080/14736480802261459

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford, CA: Stanford University Press.

Fetterman, D. M. (2010). *Ethnography step-by-step*. Los Angeles, CA: Sage Publications.

Fleury, S. C. (1997). Science in social studies: Reclaiming science for social knowledge. In E. W. Ross (Ed.), *The social studies curriculum: Purposes, problems, and possibilities* (pp. 165-182). Albany, New York: SUNY Press.

Freire, P. (2000). *Pedagogy of the oppressed*. New York: Continuum.

Fuligni, A. J., & Stevenson, H. W. (1995). Time use and mathematics achievement among American, Chinese, and Japanese high school students. *Child Development*, *66*(3), 830–842. doi:10.2307/1131953

Galligan, L. (2001). Possible effects of English-Chinese language differences on the processing of mathematical text: A review. *Mathematics Education Research Journal*, *13*(2), 112–132. doi:10.1007/BF03217102

Gay, G. (2000). *Culturally responsive teaching: Theory, research, and practice*. New York: Teachers College Press.

Giles, H., & Dorjee, T. (2005). Cultural identity in Tibetan diasporas. *Journal of Multilingual and Multicultural Development*, *26*(2), 138–157. doi:10.1080/01434630508668401

Gillette, D. D., Lowham, E., & Haungs, M. (2014). When the hurly-burly's done, of battles lost and won: How a hybrid program of study emerged from the toil and trouble of stirring liberal arts into an engineering cauldron at a public polytechnic. *Engineering Studies*, *6*(2), 108–129. doi:10.1080/19378629.2014.944186

Giroux, H. A. (2013). *America's education deficit and the war on youth*. New York: Monthly Review Press.

Global Peace Initiatives for Women. (n.d.). *GPIW Board of Directors 2013*. Retrieved from http://www.gpiw.org/about/board.html

Goodman, G. S. (2010). Critical thinking: How good questions affect classrooms. In G. S. Goodman (Ed.), *Educational psychology reader: The art and science of how people learn* (pp. 3–13). New York: Peter Lang Publishing, Inc.

Grammaticas, D. (2010, July 15). Is development killing Tibet's way of life? *BBC News Asia-Pacific.* Retrieved from http://www.bbc.com/news/world-asia-pacific-10638506

Grantome. (2014). Research: “Making connections: Exploring culturally-relevant maker experiences through an iterative, cross-institutional approach.” Retrieved October 7, 2014, from http://grantome.com/grant/NSF/DRL-1323584

Greer, B., Mukhopadhyay, S., Powell, A. B., & Nelson-Barber, S. (Eds.). (2009). *Culturally responsive mathematics education*. New York: Routledge.

Grimes, S. (2010). Cultural understanding: A crucial responsibility of language teachers abroad. *Schools: Studies in Education*, *7*(1), 27–40. doi:10.1086/651292

Gupta, A. (2007). Schooling in India. In A. Gupta (Ed.), *Going to school in South Asia* (pp. 66–111). Westport, CT: Greenwood Publishing Group.

Gutiérrez Baldoquín, H. (2004). *Dharma, color, and culture: New voices in Western Buddhism*. Berkeley, CA: Parallax Press.

Gyatso, V. L. (2006). *Harmony of emptiness and dependent-arising.* Dharamsala, HP, India: Library of Tibetan Works and Archives.

Hansen, P. H. (2002). Why is there no subaltern studies for Tibet? *Tibet Journal*, *28*(4), 7–22. Retrieved from http://users.wpi.edu/~phansen/articles/subaltern-tibet.pdf

Hayes, N., & Introna, L. D. (2005). Cultural values, plagiarism, and fairness: When plagiarism gets in the way of learning. *Ethics & Behavior*, *15*(3), 213–231. doi:10.1207/s15327019eb1503_2

Hazzan, O., & Dubinsky, Y. (2005, July). *Clashes between culture and software development methods: The case of the Israeli hi-tech industry and extreme programming*. Paper presented at the 2005 Agile Conference, Denver, CO, USA. doi:10.1109/ADC.2005.17

Head Office, Tibetan Children's Villages. (2007). *TCV educational manual*. Himachal Pradesh, India: Hero Printers.

Herman, W. E., & Bailey, M. P. (1991). Recommendations for teaching overseas. *College Teaching*, *39*(3), 117–121. doi:10.1080/87567555.1991.10532443

Herskovits, M. J. (1955). *Cultural anthropology*. New York: Knopf.

Hill, C. (2009). What's the matter with saying "the Orient"? Retrieved November 23, 2014, from http://aboutjapan.japansociety.org/content.cfm/whats_the_matter_with_saying_the_orient

Hofstede, G. (2011). Dimensionalizing cultures: The Hofstede model in context. *Online Readings in Psychology and Culture*, *2*(1). doi:10.9707/2307-0919.1014

Hsu, C.-F. (2012). The influence of vocal qualities and confirmation of nonnative English-speaking teachers on student receiver apprehension, affective learning, and cognitive learning. *Communication Education*, *61*(1), 4–16. doi:10.1080/03634523.2011.615410

Hsu, P.-L., & Roth, W.-M. (2010). From a sense of stereotypically foreign to belonging in a science community: Ways of experiential descriptions about high school students' science internship. *Research in Science Education*, *40*(3), 291–311. doi:10.1007/s11165-009-9121-5

Immigration and Refugee Board of Canada. (2011). *India: The 22 December 2010 Delhi High Court ruling that Namgyal Dolkar, a Tibetan woman born in India, is entitled to claim Indian citizenship by birth, as per the Citizenship Act*. Retrieved from http://www.refworld.org/docid/50b48ebc2.html

Jian, H. L., & Sandnes, F. E. (2009, December). *Taiwanese and Norwegian engineering students' self-image of academic abilities, grades and course satisfaction*. Paper presented at the IEEE International Conference on Industrial Engineering and Engineering Management, Hong Kong, China. doi:10.1109/IEEM.2009.5373521

Jinpa, T. (2010). Buddhism and science: How far can the dialogue proceed? *Zygon®*, *45*(4), 871–882. doi:10.1111/j.1467-9744.2010.01138.x

Johnson, R. A., & Schulman, G. I. (1989). Gender-role composition and role entrapment in decision-making groups. *Gender & Society*, *3*(3), 355–372. doi:10.1177/089124389003003005

Johri, A. (2009, October). *Preparing engineers for a global world: Identifying and teaching strategies for sensemaking and creating new practices*. Paper presented at the 2013 IEEE Frontiers in Education Conference, Los Alamitos, CA, USA. doi:10.1109/FIE.2009.5350616

Jollands, M., & Parthasarathy, R. (2013). Developing engineering students' understanding of sustainability using project based learning. *Sustainability*, *5*(12), 5052–5066. doi:10.3390/su5125052

Joyce, A., Earnest, J., Mori, G. de, & Silvagni, G. (2010). The experiences of students from refugee backgrounds at universities in Australia: Reflections on the social, emotional and practical challenges. *Journal of Refugee Studies*, *23*(1), 82–97. doi:10.1093/jrs/feq001

Kabo, J., & Baillie, C. (2009). Seeing through the lens of social justice: A threshold for engineering. *European Journal of Engineering Education*, *34*(4), 317–325. doi:10.1080/03043790902987410

Kaplan, I. (2009). Effects of trauma and the refugee experience on psychological assessment processes and interpretation. *Australian Psychologist*, *44*(1), 6–15. doi:10.1080/00050060802575715

Kapstein, M. (2006). *The Tibetans*. Malden, MA: Blackwell Publishers.

Karp, L., & Lee, I. H. (2001). Learning-by-doing and the choice of technology: The role of patience. *Journal of Economic Theory*, *100*(1), 73–92. doi:10.1006/jeth.2000.2727

Kasl, E., & Elias, D. (2000). Creating new habits of mind in small groups. In J. Mezirow (Ed.), *Learning as transformation: Critical perspectives on a theory in progress* (pp. 229–252). San Francisco, CA: Jossey-Bass Publishers.

Kaza, S., & Kraft, K. (Eds.). (2000). *Dharma rain: Sources of Buddhist environmentalism*. Boston, MA: Shambhala Publications.

Kessels, U., Rau, M., & Hannover, B. (2006). What goes well with physics? Measuring and altering the image of science. *British Journal of Educational Psychology*, *76*(4), 761–780. doi:10.1348/000709905X59961

Kevern, J. (2011). Green building and sustainable infrastructure: Sustainability education for civil engineers. *Journal of Professional Issues in Engineering Education and Practice*, *137*(2), 107–112. doi:10.1061/(ASCE)EI.1943-5541.0000048

Kristensen, H. J., & Sørensen, B. L. (2004). An example of how assessment relates to practice when student learning is the main principle for creating curricula. *European Journal of Engineering Education*, *29*(2), 203–209. doi:10.1080/03043790310001633188

Kitchenham, A. (2008). The evolution of John Mezirow's transformative learning theory. *Journal of Transformative Education*, *6*(2), 104–123. doi:10.1177/1541344608322678

Kivrak, S., Arslan, G., Tuncan, M., & Birgonul, M. T. (2014). Impact of national culture on knowledge sharing in international construction projects. *Canadian Journal of Civil Engineering*, *41*(7), 642–649. doi:10.1139/cjce-2013-0408

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall.

Ladson-Billings, G. (1995). But that's just good teaching! The case for culturally relevant pedagogy. *Theory Into Practice*, *34*(3), 159–165. doi:10.1080/00405849509543675

Lahelma, E. (2002). Gendered conflicts in secondary school: Fun or enactment of power? *Gender & Education*, *14*(3), 295–306. doi:10.1080/0954025022000010749

Lau, A. S. (2007). Green design in first-year engineering. *International Journal of Engineering Education*, *23*(2), 276–286. Retrieved from http://www.cede.psu.edu/users/alau/Ijee1903.pdf

Layton, E. T. (1971). *The revolt of the engineers: Social responsibility and the American engineering profession*. Cleveland, OH: Press of Case Western Reserve University.

Lee, H., & Liebenau, J. (1999). Time in organizational studies: Towards a new research direction. *Organization Studies*, *20*(6), 1035–1058. doi:10.1177/0170840699206006

Lindsay, B. C. (2014). Humor and dissonance in California's Native American genocide. *American Behavioral Scientist*, *58*(1), 97–123. doi:10.1177/0002764213495034

Liss, J. M. (2013). Creative destruction and globalization: The rise of massive standardized education platforms. *Globalizations*, *10*(4), 557–570. doi:10.1080/14747731.2013.806741

Little, A. W. (1996). Globalisation and educational research: Whose context counts? *International Journal of Educational Development*, *16*(4), 427–438. doi:10.1016/S0738-0593(96)00063-6

López, D. S. (1998). *Prisoners of Shangri-La: Tibetan Buddhism and the West*. Chicago, IL: University of Chicago Press.

López, D. S. (2002). *The story of Buddhism: A concise guide to its history & teachings*. San Francisco, CA: HarperCollins.

López, D., Sánchez, F., Cruz, J.-L., & Fernández, A. (2007, October). *Developing non-technical skills in a technical course*. Paper presented at the 37th ASEE/IEEE Frontiers in Education Conference, Milwaukee, WI. doi:10.1109/FIE.2007.4417825.

loQal.ph, & Yahoo! Southeast Asia. (2011, July 4). *Plastic soda bottles become light source* [Video file]. Retrieved from http://www.youtube.com/watch?v=kHTD_RX3J2I

Lohmann, J. R., Rollins, H. A., & Hoey, J. (2006). Defining, developing and assessing global competence in engineers. *European Journal of Engineering Education*, *31*(1), 119–131. doi:10.1080/03043790500429906

Lucena, J., Downey, G., Jesiek, B., & Elber, S. (2008). Competencies beyond countries: The re-organization of engineering education in the United States, Europe, and Latin America. *Journal of Engineering Education*, *97*(4), 433–447. doi:10.1002/j.2168-9830.2008.tb00991.x

Lucena, J., & Schneider, J. (2008). Engineers, development, and engineering education: From national to sustainable community development. *European Journal of Engineering Education*, *33*(3), 247–257. doi:10.1080/03043790802088368

Lucena, J., Schneider, J., & Leydens, J. A. (2010). Engineering and sustainable community development. *Synthesis Lectures on Engineers, Technology and Society*, *5*(1), 1–230. doi:10.2200/S00247ED1V01Y201001ETS011

Lucena, J. (Ed.) (2013). *Engineering education for social justice: Critical explorations and opportunities*. Dordrecht, Netherlands: Springer. doi: 10.1007/978-94-007-6350-0

Macduff, I. (2006). Your pace or mine? Culture, time, and negotiation. *Negotiation Journal*, *22*(1), 31–45. doi:10.1111/j.1571-9979.2006.00084.x

MacPherson, S., & Ghoso, D. B. (2008). Multilingualism in emerging diasporas: A Tibetan case study. *Diaspora, Indigenous, and Minority Education*, *2*(3). doi:10.1080/15595690802145414

Mainwaring, D., & Markowski, K. (1991). Cultural factors in the structure and context of European engineering studies. *European Journal of Engineering Education*, *16*(4), 299–307. doi:10.1080/03043799108939536

Maslak, M. A. (2008). School as a site of Tibetan ethnic identity construction in India? Results from a content analysis of textbooks and Delphi study of teachers' perceptions. *Educational Review*, *60*, 85–106. doi:10.1080/00131910701794671

Mason, K. (2001). *Brick by brick: Participatory technology development in brickmaking*. London, UK: ITDG Publishing.

Matsuishi, M., & Kitamura, T. (2006, June). *Introductory pre-college engineering design course based upon collaborative learning to high school students*. Paper presented at the 2006 IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing, 2006, Taichung, Taiwan. doi:10.1109/SUTC.2006.82

Merriam, S. B., & Ntseane, G. (2008). Transformational learning in Botswana: How culture shapes the process. *Adult Education Quarterly*, *58*(3), 183–197. doi:10.1177/0741713608314087

Meyer, E. J. (2008). Gendered harassment in secondary schools: Understanding teachers' (non) interventions. *Gender & Education*, *20*(6), 555–570. doi:10.1080/09540250802213115

Mezirow, J. (1991). *Transformative dimensions of adult learning*. San Francisco, CA: Jossey-Bass.

Mezirow, J. (2000). Learning to think like an adult: Core concepts of transformational theory. In J. Mezirow (Ed.), *Learning as transformation: Critical perspectives on a theory in progress* (pp. 3–33). San Francisco, CA: Jossey-Bass.

Mind & Life Institute. (2014). *Past conferences: Mind & Life Institute*. Retrieved from http://www.mindandlife.org/dialogues/past-conferences/

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks, CA: Sage Publications.

Minkov, M., & Hofstede, G. (2011). The evolution of Hofstede's doctrine. *Cross Cultural Management: An International Journal*, *18*(1), 10–20. doi:10.1108/13527601111104269

Misra, A. (2003). A nation in exile: Tibetan diaspora and the dynamics of long distance nationalism. *Asian Ethnicity*, *4*(2), 189–206. doi:10.1080/14631360301659

Mitchell, D. W. (2008). *Buddhism: Introducing the Buddhist experience.* New York, NY: Oxford University Press.

Morrison, K., Robbins, H. H., & Rose, D. G. (2008). Operationalizing culturally relevant pedagogy: A synthesis of classroom-based research. *Equity & Excellence in Education*, *41*(4), 433–452. doi:10.1080/10665680802400006

Moynihan, M. (2012a, August 25). Tibetans in India: The case for citizenship [Web log message]. Retrieved from http://www.rangzen.net/2012/08/25/tibetans-in-india-the-case-for-citizenship/

Moynihan, M. (2012b, October 28). Tibetans in exile – Passports or RC's: Who gets what? [Web log message]. Retrieved from http://www.rangzen.net/2012/10/28/tibetans-in-exile-%e2%80%93-passports-or-rc%e2%80%99s-who-gets-what/

Müller, R., Spang, K., & Özcan, S. (2009). Cultural differences in decision making in project teams. *International Journal of Managing Projects in Business*, *2*(1), 70–93. doi:10.1108/17538370910930527

Munakata-Marr, J., Leydens, J. A., & Moskal, B. M. (2009). *Beyond technical issues: A case-study approach to introducing environmental engineering students to nontechnical wastewater engineering constraints*. Paper presented at the Proceedings of the 39th IEEE International Conference on Frontiers in Education Conference, Piscataway, NJ, USA.

Mundada, M. N., Kumar, S., & Shekdar, A. V. (2004). E-waste: A new challenge for waste management in India. *International Journal of Environmental Studies*, *61*(3), 265–279. doi:10.1080/0020723042000176060

Murphy, R. (2004). Turning peasants into modern Chinese citizens: Discourse, demographic transition and primary education. *The China Quarterly*, *177*, 1–20. doi:10.1017/S0305741004000025

National Academy of Engineering. (2004). *The engineer of 2020.* Washington, DC: National Academies Press.

National Academy of Engineering. (2008). *Changing the conversation: Messages for improving public understanding of engineering*. Washington, DC: National Academies Press.

Nelson, L. A. (2011). Research and development strategies for innovations that alleviate poverty. *Studies in Material Thinking*, *6*(December 2011). Retrieved from http://www.materialthinking.org/sites/default/files/papers/Nelson.pdf

Nnorom, I. C., & Osibanjo, O. (2008). Overview of electronic waste (e-waste) management practices and legislations, and their poor applications in the developing countries. *Resources, Conservation and Recycling*, *52*(6), 843–858. doi:10.1016/j.resconrec.2008.01.004

Noble, D. F. (1979). *America by design: Science, technology, and the rise of corporate capitalism*. New York: Alfred A. Knopf, Inc.

Norbu, J. (2012, November 6). Make it a burning issue [Web log message]. Retrieved from http://www.rangzen.net/2012/11/06/make-it-a-burning-issue/

Norbu, J. (2013, October 31). The sad painful joke of Tibetan democracy [Web log message]. Retrieved from http://www.rangzen.net/2013/10/31/the-sad-painful-joke-of-tibetan-democracy/

Norling, P. M. (2009). In innovation, is patience a virtue? *Research Technology Management*, *52*(3), 18–23.

Oakes, W., Duffy, J., Jacobius, T., Linos, P., Lord, S., Schultz, W. W., & Smith, A. (2002, November). *Service-learning in engineering*. Paper presented at FIE 2002, Boston, MA. doi:10.1109/FIE.2002.1158178

Ochieng, E. G., & Price, A. D. (2009). Framework for managing multicultural project teams. *Engineering, Construction and Architectural Management*, *16*(6), 527–543. doi:10.1108/09699980911002557

Ochieng, E. G., Price, A. D. F., Ruan, X., Egbu, C. O., & Moore, D. (2013). The effect of cross-cultural uncertainty and complexity within multicultural construction teams. *Engineering, Construction and Architectural Management*, *20*(3), 307–324. doi: 10.1108/09699981311324023

O'Connor, L. E., Berry, J. W., Stiver, D. J., & Rangan, R. K. (2012). Depression, guilt, and Tibetan Buddhism. *Psychology*, *03*(29), 805–809. doi:10.4236/psych.2012.329122

Palkyi, T. (2011). *Analyzing educational attainments and occupational outcomes of Tibetan refugees living in India* (Unpublished master's thesis). University of Kentucky, Kentucky, USA. Retrieved from http://uknowledge.uky.edu/gradschool_theses/121

Patton, M. (2002). *Qualitative research and evaluation methods*. Thousand Oaks, CA: Sage Publications.

Paul, S., & Bhattacharya, R. N. (2004). Causality between energy consumption and economic growth in India: A note on conflicting results. *Energy Economics*, *26*(6), 977–983. doi:10.1016/j.eneco.2004.07.002

Pellow, D. N. (2007). *Resisting global toxics: Transnational movements for environmental justice*. Cambridge, MA: MIT Press.

Peña, M. F., Conesa, D. G., Hassan, H., & Ballester, E. (2009, June). *Multidisciplinary and international projects*. Paper presented at the 2009 EAEEIE Annual Conference, Valencia, Spain. doi:10.1109/EAEEIE.2009.5335454

Perdue, D. (1992). *Debate in Tibetan Buddhism*. Ithaca, NY, USA: Snow Lion Publications.

Petroski, H. (2001). The success of failure. *Technology and Culture*, *42*(2), 321–328. doi:10.1353/tech.2001.0078

Phayul. (2012, May 22). Geshema degree becomes a reality. *Phayul*. Retrieved from http://www.phayul.com/news/article.aspx?id=31441&t=1

Phayul. (2013a, April 25). Buddhist nuns attend empowerment programme. *Phayul*. Retrieved from http://www.phayul.com/news/article.aspx?id=33369&t=1

Phayul. (2013b, November 4). Dalai Lama meets nun participants of the Great Winter Debate. *Phayul.* Retrieved from http://www.phayul.com/news/article.aspx?id=34170&t=1

Phuntsog, N. (1998). Cultural identity and schooling of Tibetan children in the diaspora. *Equity & Excellence in Education*, *31*(1), 36–39. doi:10.1080/1066568980310106

Phuntsog, N. (1999). The magic of culturally responsive pedagogy: In search of the genie's lamp in multicultural education. *Teacher Education Quarterly*, *26*(3), 97-111.

Pommaret, F. (2003). *Tibet: A wounded civilization*. New York: Harry N. Abrams.

Poole, M., & Isaacs, D. (1997). Caring: A gendered concept. *Women's Studies International Forum*, *20*(4), 529–536. doi:10.1016/S0277-5395(97)00041-1

Posner, B. Z. (1987). What it takes to be a good project manager. *Project Management Journal*, *18*(1), 51–54.

Practical Action. (n.d.). *Micro-hydro power*. Retrieved from http://practicalaction.org/docs/technical_information_service/micro_hydro_power.pdf

Pritchard, J., & Baillie, C. (2006). How can engineering education contribute to a sustainable future? *European Journal of Engineering Education*, *31*(5), 555–565. doi:10.1080/03043790600797350

Purdue University. (2014). *Course descriptions*. Retrieved November 22, 2014, from https://engineering.purdue.edu/ENE/Academics/Graduate/Doctorate/courses#PCA

Quayle, A. J. (2010, April). *A strategic framework for engineering education and practice*. Paper presented at the 2010 IEEE Transforming Engineering Education: Creating Interdisciplinary Skills for Complex Global Environments, Dublin, Ireland. doi:10.1109/TEE.2010.5508869

Rainnie, D. G., & Ressler, K. J. (2009). Physiology of the amygdala: Implications for PTSD. In J. E. LeDoux, T. Keane, & P. Shiromani (Eds.), *Post-traumatic stress disorder: Basic science and clinical practice* (pp. 39–78). Totowa: Humana Press.

Rajan, D. S. (2010). *India-China relations: An Indian perspective*. Retrieved May 21, 2014, from http://www.phayul.com/news/article.aspx?id=27622&t=1

Ransom, K. (2006). Home on the range: Case study of Kham nomadic peoples and the Litang region. *Independent study project (ISP) collection*. Retrieved from http://digitalcollections.sit.edu/isp_collection/296

Rao, R., Pawley, A. L., Hoffmann, S. R., Ohland, M. W., & Cardella, M. E. (2010). Work in progress - Development of a framework to assess sustainability knowledge (ASK) in engineering undergraduate students. Paper presented at the *40th ASEE/IEEE Frontiers in Education Conference* (pp. F1J–1–F1J–3). doi:10.1109/FIE.2010.5673618

Rasoal, C., Danielsson, H., & Jungert, T. (2012). Empathy among students in engineering programmes. *European Journal of Engineering Education*, *37*(5), 427–435. doi:10.1080/03043797.2012.708720

Reed, G. G. (2011). The complexity of moral learning: Diversity, deprovincialisation and privilege. *Journal of Moral Education*, *40*(3), 359–367. doi:10.1080/03057240.2011.596337

Rigzin, T. (2003). The Tibetan schools in the diaspora. In D. Bernstorff & H. von Welck (Eds.), *Exile as challenge: The Tibetan diaspora* (pp. 266–278). New Delhi, India: Orient Longman.

Roemer, S. (2008). *The Tibetan government-in-exile: Politics at large*. New York: Routledge.

Roth, W.-M., & Roychoudhury, A. (1992). The social construction of scientific concepts or the concept map as device and tool thinking in high conscription for social school science. *Science Education*, *76*(5), 531–557. doi:10.1002/sce.3730760507

Rothberg, D. (1998). Responding to the cries of the world: Socially engaged Buddhism in North America. In C. S. Prebish & K. K. Tanaka (Eds.), *The faces of Buddhism in America* (pp. 266–286). Berkeley, CA: University of California Press.

Said, E. W. (1994). *Orientalism*. New York: Vintage Books.

Saldaña, J. (2009). *The coding manual for qualitative researchers*. Thousand Oaks, CA: Sage.

Santiago, M. M. (2013). What can Buddhism offer to a socially just engineering education? In J. Lucena (Ed.), *Engineering education for social justice: Critical explorations and opportunities* (pp. 85–109). Netherlands: Springer. Retrieved from http://link.springer.com/chapter/10.1007/978-94-007-6350-0_5

Sarvodaya. (n.d.). *Empowerment programmes*. Retrieved September 30, 2014, from http://www.sarvodaya.org/about/empowerment-programmes

Saunders, C., Van Slyke, C., & Vogel, D. R. (2004). My time or yours? Managing time visions in global virtual teams. *Academy of Management Executive*, *18*(1), 19–31.

Scheiner, D. L. (2013). *The contribution of posttraumatic stress disorder to verbal learning and memory performance profiles in major depression* (Unpublished doctoral dissertation). Fordham University, New York. Retrieved from http://fordham.bepress.com/cgi/viewcontent.cgi?article=3595&context=dissertations

Schneider, J. (2010). Engineering and the values of social justice. *Engineering Studies*, *2*(1), 1–4. doi:10.1080/19378621003615975

Schrempf, M. (1999). Taming the Earth, controlling the cosmos: Transformation of space in Tibetan Buddhist and Bon-po ritual dance. In T. Huber (Ed.), *Sacred spaces and powerful places in Tibetan culture* (pp. 198–224). Dharamsala, HP, India: Library of Tibetan Works and Archives. Retrieved from http://iaaw.hu-berlin.de/zentralasien/staff/dr.-mona-schrempf/1999-schrempf-taming--the-earth.pdf

Scott, J. T. (1994). Politics as the imitation of the Divine in Rousseau's "social contract." *Polity*, *26*(3), 473–501. doi:10.2307/3235155

Sehgal, S. (2014). *Tibetans-in-exile divided over right to vote in Indian elections*. Retrieved from http://www.theguardian.com/world/2014/may/07/tibetans-in-exile-india-elections-right-to-vote

Servan-Schreiber, D., Le Lin, B., & Birmaher, B. (1998). Prevalence of posttraumatic stress disorder and major depressive disorder in Tibetan refugee children. *Journal of the American Academy of Child and Adolescent Psychiatry*, *37*(8), 874–879.

Setati, M. (2002). Researching mathematics education and language in multilingual South Africa. *Mathematics Educator*, *12*(2), 6–20.

Shakya, T. (1999). *The dragon in the land of snows: A history of modern Tibet since 1947*. New York: Columbia University Press.

Shantideva. (1979). *A guide to the Bodhisattva's way of life.* New Delhi, India: Indraprastha Press.

Sharholy, M., Ahmad, K., Mahmood, G., & Trivedi, R. C. (2008). Municipal solid waste management in Indian cities – A review. *Waste Management*, *28*(2), 459–467. doi:10.1016/j.wasman.2007.02.008

Shi, L. (2009). Chinese-Western "contact zone": Students' resistance and teachers' adaptation to local needs. *TESL Canada Journal*, *27*(1), 47-63. Retrieved from http://www.teslcanadajournal.ca/index.php/tesl/article/viewFile/1035/854

Shi, Z. Y. (2011, June). *Than Hsiang Kalyana Mitra Centre in Pajam, Negeri Sembilan: A case study*. Paper presented at the 12th Sakyadhita International Conference on Buddhist Women: Leading to Liberation, Bangkok, Thailand (pp. 202–204).

Siddiqui, J. (2014). *Transformation of engineering education: Taking a perspective for the challenges of change* (Unpublished doctoral dissertation). Purdue University, West Lafayette, IN.

Singer, M., Radinsky, J., & Goldman, S. R. (2008). The role of gesture in meaning construction. *Discourse Processes*, *45*(4-5), 365–386. doi:10.1080/01638530802145601

Singh, A. (2004, September 24). *An introduction to Edward Said, orientalism, and postcolonial literary studies*. Retrieved from http://www.lehigh.edu/~amsp/2004/09/introduction-to-edward-said.html

Singh, S. (2011, July 27). NID prof wins award for load carrier. *Ahmedabad Mirror*. Retrieved from http://epaper.timesofindia.com/Repository/getFiles.asp?Style=OliveXLib:LowLevelEntityToPrint_MIRRORNEW&Type=text/html&Locale=english-skin-custom&Path=AMIR/2011/07/27&ID=Ar01101

Slaton, A. E. (2010). *Race, rigor and selectivity in U.S. engineering: History of an occupational color-line*. Boston, MA: Harvard University Press.

Slavkin, M. (2001). Problem solving in the natural sciences and early adolescent girls' gender roles and self-esteem: A qualitative and quantitative analysis from an ecological perspective. *Journal of Women and Minorities in Science and Engineering*, *7*(3). doi: 10.1615/JWomenMinorScienEng.v7.i3.50

Sleeter, C. E. (2012). Confronting the marginalization of culturally responsive pedagogy. *Urban Education*, *47*(3), 562–584. doi:10.1177/0042085911431472

Smith, K. A., & Imbrie, P. K. (2000). *Teamwork and project management*. Boston, MA: McGraw-Hill Higher Education.

Smith, K. A., Sheppard, S. D., Johnson, D. W., & Johnson, R. T. (2005). Pedagogies of engagement: Classroom-based practices. *Journal of Engineering Education*, *94*(1), 87–101. doi:10.1002/j.2168-9830.2005.tb00831.x

Smith, L. T. (1999). *Decolonizing methodologies: Research and indigenous peoples*. New York: Zed Books.

Spencer, J. (1995). Occidentalism in the East: The uses of the West in the politics and anthropology of South Asia. In J. Carrier (Ed.), *Occidentalism: Images of the West* (pp. 234–257). New York: Oxford University Press.

Strauss, A. L., & Corbin, J. M. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Thousand Oaks, CA: Sage Publications.

Svinicki, M. D. (2004). *Learning and motivation in the postsecondary classroom*. Bolton, MA: Anker.

Swan, A. K. (2012). Female students' experiences with project-based work in introductory engineering classes at two- and four-year institutions. *Journal of Women and Minorities in Science and Engineering*, *18*(4), 337–357. doi:10.1615/JWomenMinorScienEng.2013004350

Swank, H. (2011). A wanderer in a distant place: Tibetan exile youth, literacy, and emotion. *International Migration*, *49*(6), 50–73. doi:10.1111/j.1468-2435.2011.00703.x

The Office of His Holiness the Dalai Lama. (n.d.). *His Holiness's Middle Way approach for resolving the issue of Tibet*. Retrieved from http://www.dalailama.com/messages/middle-way-approach

Thomas, I. (2009). Critical thinking, transformative learning, sustainable education, and problem-based learning in universities. *Journal of Transformative Education*, *7*(3), 245–264. doi:10.1177/1541344610385753

Tibetan Children's Villages. (n.d.a). *Day school*. Retrieved from http://www.tcv.org.in/day-school

Tibetan Children's Villages. (n.d.b). *Residential schools*. Retrieved from http://www.tcv.org.in/residential-schools

Tibetan Children’s Villages. (n.d.c.). *Historical background*. Retrieved from http://www.tcv.org.in/content/historical-background

TCV Selakui Blog. (2014). *2014 First term consolidated results of different classes*. Retrieved from http://tcvmagnetschoolworkpress.wordpress.com/2014-first-term-consolidated-results-of-different-classes/

Tonso, K. L. (2006). Teams that work: Campus culture, engineer identity, and social interactions. *Journal of Engineering Education*, *95*(1), 25–37. doi:10.1002/j.2168-9830.2006.tb00875.x

Tonso, K. L. (2007). *On the outskirts of engineering: Learning identity, gender, and power via engineering practice*. Rotterdam, Netherlands: Sense.

Tsering, T. (2012, April 2). *Tibet burning: The politics of self immolations*. Retrieved from http://www.rangzen.net/2012/04/02/tibet-burning-the-politics-of-self-immolations

United Nations Development Programme. (2013). *Sustainable energy*. Retrieved from http://www.undp.org/content/undp/en/home/ourwork/environmentandenergy/focus_areas/sustainable-energy.html

Van Cleave, N. (2001). Components of an American Indian computer science transfer degree program. *Journal of Engineering Education*, *90*(1), 55–61. doi:10.1002/j.2168-9830.2001.tb00567.x

Vandermensbrugghe, J. (2004). The unbearable vagueness of critical thinking in the context of the Anglo-Saxonisation of education. *International Education Journal*, *5*(3), 417–422.

Vijithananda, B. M. (2011, June). *Children's ethics programs at the Sakyadhita Center, Sri Lanka*. Paper presented at the *12th Sakyadhita International Conference on Buddhist Women: Leading to Liberation* (pp. 198–201), Bangkok, Thailand.

Vogt, L. A., Jordan, C., & Tharp, R. G. (1987). Explaining school failure, producing school success: Two cases. *Anthropology & Education Quarterly*, *18*(4), 276–286. doi:10.1525/aeq.1987.18.4.04x0019s

Vosniadou, S. (2009). 'Conceptual metaphor meets conceptual change': Yes to embodiment, no to fragmentation. *Human Development*, *52*(3), 198–204. doi:10.1159/000213892

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Waste for Life. (2013). *Waste for life*. Retrieved from http://wasteforlife.org/

Weber, M. (2013). *The Protestant ethic and the spirit of capitalism*. London, UK: Routledge.

Whalen-Bridge, J. (2011). Multiple modernities and the Tibetan diaspora. *South Asian Diaspora*, *3*(1), 103-115. doi:10.1080/19438192.2010.539039

White, L. T., Valk, R., & Dialmy, A. (2011). What is the meaning of "on time"? The sociocultural nature of punctuality. *Journal of Cross-Cultural Psychology*, *42*(3), 482-493. doi:10.1177/0022022110362746

Wieder, A. (1999). The Tibetan Children's Village: A narrative-photographic essay. *Multicultural Perspectives*, *1*(1), 18-23. doi:10.1080/15210969909539881

Wilson, J. (2012). *Dixie Dharma: Inside a Buddhist temple in the American South*. Chapel Hill, NC: University of North Carolina Press.

Winner, L. (1993). Social constructivism: Opening the black box and finding it empty. *Science as Culture*, *3*(3), 427-452. doi:10.1080/09505439309526358

Wolcott, H. F. (2008). *Ethnography: A way of seeing*. Lanham, MD: Altamira Press.

Yin, R. K. (2009). *Case study research: Design and methods*. Los Angeles, CA: Sage Publications.

APPENDICES

Appendix A Progress report guidelines #1

First Phase of your Engineering Design Project: Identify a Need (Problem) in your School

(DUE DATE: September 12th)

Why I am asking you to submit progress reports?

- **Imagine that you are an engineer in a team** ☺. To help you have a *practical experience* in an engineering design project, we are going to divide your project in phases (or stages), just as engineers divide their work.
- I am going to give you a set of instructions and questions to follow on each phase.
    - The instructions are to guide you throughout your design project
    - The questions are to help you reflect on your work. They will also help me understand what you did.
- Engineers also write every week (or every month) progress reports or presentations to their clients or supervisors to inform them of their work done so far. Usually they inform this in a meeting.

How this work relates to the *real* work of an engineer?

- **With your team, you are going to identify a need in the school**. **This will be the problem that you will solve with your team.**
- You are going to write a *problem statement.* Engineers have to write *problem statements* in the beginning of their project. Problem statements describe:
    - *What* is the need (problem)
    - *Who* are experiencing the problem
    - *How* does the problem affects the people
    - *When* does the problem happen
    - *Where* does the problem happen

- *Problem statements* are part of the documentation that engineers give to a "client." A "client" in real life can be a government agency, school, village, group of people, NGO, etc.
    - To understand the needs of a "client," engineers have to listen to their clients' needs, ask questions, and investigate. Similar to the interview that you will do (see "instructions").

How this work relates to the *real* work of an engineering student?

- In many universities, first-year engineering students need to do an engineering design project like this, but in a larger scale. They usually spend 1-2 semesters doing their project.

I. Instructions:

1) **Choose a problem in the school**. The problem must be *real*: at least one person should have expressed that he or she needs help to solve it.
    a. The problem should be one that (a) you are comfortable to work with and (b) you can design a solution for it in a month.
2) **Investigate about the problem: Interview at least one person who has been suffering the consequences of this problem**. Write a summary about your interview following these questions:
    a. *Who* you interviewed?
    b. *What* is the problem that the person is suffering?
    c. *When and where* does this problem happen?
    d. *What ideas* he or she has on how to solve the problem? (if any)
    e. *How* he or she has tried to solve it before? (if applicable)
    f. Are there other people suffering this problem?
    g. If you can, take a photo of the area where this problem happens
3) Based on your investigation, **write a problem statement (see examples on section IV).** 3-5 lines is enough.
4) **Answer some of the questions in Section II.**

II. Other questions to answer

1) Is people's **health** being affected because of this problem? – If "yes", please explain how.

2) Are there **social problems** associated to this problem? – If "yes", please explain how.
3) Is the **environment** being affected because of this problem? – If "yes", please explain how.
4) Does the problem relate to Tibetan culture and/or Buddhism? – If "yes", please explain how.
5) Do you think that your knowledge in **Tibetan dialectics** is helping you in
    - **a.** Team work
    - **b.** Understanding the problem

    If "yes", please explain how.
6) Do you think that ཕ་རོལ་ཏུ་ཕྱིན་པ་དྲུག་ (སྦྱིན་པ་, ཚུལ་ཁྲིམས་, བཟོད་པ་, བརྩོན་འགྲུས་, བསམ་གཏན་, ཤེས་རབ་) are helping you in
    - **a.** Team work
    - **b.** Understanding the problem

    If "yes," please explain how.
7) Do you think that Tibetan values and beliefs are helping you in
    - **a.** Team work
    - **b.** Understanding the problem

    If "yes", please explain how.
8) What knowledge of physics, mathematics, or science do you think that you will need to apply in order to design a solution for the problem? *(if you don't know yet, leave it blank)*
9) Which engineering discipline (branch) do you think that your problem relates to? (*Examples: hydraulics, materials, mechanical, biomedical, civil, electrical, sustainable)*
10) *(If applicable)* If you faced difficulties in team work or in understanding the problem:
    - **a.** What were those difficulties?
    - **b.** How did you overcome those difficulties? *(if applicable)*
11) *(If applicable)* Did you get help from someone else outside of your group? If "yes", then who?

III. Rules:

1. **Each group must have a unique problem to solve. ☺ When you choose your problem, make sure that other groups do not have the same one!**
2. Your report will be in English. It is okay to write key words in Tibetan (as long as you tell its meanings).
3. You can handwrite the report. No need to submit a file.
4. You can write in both sides of the paper. Tell me if you need papers.
5. Write each question and its number again. You can use **…** when the question is too long. For example:

    "9) Which engineering discipline …"

6. **Your report should have three sections:**

I. Investigation about the problem

[Summary of your interview and investigation]

II. Problem statement

III. Answer to other questions

7. **Length of report:** 2-5 pages
8. There is no need to record the interview; however, you are free to do so if you wish
9. If you can, please, take photos that relate to the problem
10. Photos or videos that you wish to add in your reports can be put in a flash drive, or SD camera memory card, or in a DVD. I will pass them to my laptop. Alternatively, bring the camera with cable on the day of your report submission. If you need a flash drive, I will bring one to the class

*** Let me know when you need help. We are here to help you succeed! ☺ ***

IV. Examples of Problem Statements:

A. Related to Civil and Mechanical Engineering

- The school has approximately 15 dogs. The school does not have money to neuter or vaccinate them, thus, it can be risky for the people's health to leave the dogs on campus. The students and administration wish to keep 5 dogs on campus because they help to run away the monkeys, but the rest of the dogs need to leave. **The school has expressed the need to have a device to catch the dogs and transport them outside of the school without harming them.**

- The childcare center assistant complained to the administration that small children escape from the building to play outside. She has seen snakes around the area and she has fear that these snakes would bite a child. **She has expressed the need to have something that can help her maintain the children inside the building**. She has ideas of a child-proof door, but she needs extra help from students to design a better child-proof door.

B. Related to Biomedical Engineering

- Several Indian workers in school need to carry heavy loads of tree branches on their back in the monsoon season. One of them has a severe back problem and **he has expressed the need to have a device that will facilitate the transportation of branches from the high school to the outside gate**. The device needs to be efficient on a rocky path (such as the road in front of the administration building).

C. Related to Materials Engineering

- The Welfare group has been making mops using bamboo and old clothing rags. **Students have expressed a need to know what type of clothing are the best to make a mop that dries X buckets of water in less than 1 minute**. They have cloths of cotton, polyester, rayon, nylon, silk, and wool.

Appendix B Progress report guidelines #2

Second Phase of your Engineering Design Project: Causes and Conditions

(DUE DATE: September ~~19th~~ 24th)

<u>How this work relates to the *real* work of an engineer?</u>

- In this phase, we will
    (1) define requirements and constraints for your design
    (2) brainstorm/draw possible solutions
    (3) think of what materials you will use
    (4) think of how your design works in terms of physics, math, and other sciences

…Many of you already started drawing solutions for your problem. That is great. Engineers also draw initial sketches in their early stages. ☺

- Clear requirements and constraints are like guiding posts for engineers. What is the difference?
    - You first identify design requirements and then you limit them with constraints
    - Constraints limit your design to the context and resources available

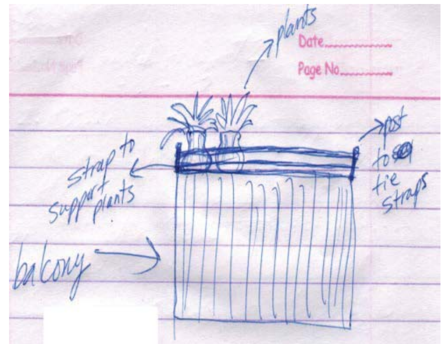
I. Instructions:

5) **Requirement for all teams:**
    a. **Solution *must* be environmentally-friendly (sustainable)**
    b. **Solution *must* use local resources**
6) Use your critical thinking and Report 1 investigation to **write other requirements and constraints**
    a. *At least*, **write 4 requirements and 3 constraints**
    b. You are free to write more
    c. **See an example in Section IV**
7) **Draw possible solutions for your problem**. ☺

a. You can do this in collaboration with other team members

b. If you started drawing, use your critical thinking skills to reconsider other aspects of your design

c. **Please, explain to me the parts of your design. Simple example →**



8) Think about **materials that you will use** in your design

9) Think about **how your design works in terms of physics, math, and other sciences**

10) **Please, take photos when your team is working**. It would be great to show (in your final presentation) how your team worked. ☺ It also will help me evaluate your work**.**

11) **Answer questions on Section II.**

II. Questions:

NOTE: you can answer some of these questions by providing examples of your team's experiences

12) What **materials** are you thinking of using for your design? Why?

13) Write at least one paragraph that explains **how your design works** using physics, math, and sciences knowledge.

14) How do you think that your knowledge in **Tibetan dialectics** is helping you?

15) How do you think that ཕ་རོལ་ཏུ་ཕྱིན་པ་དྲུག་ (སྦྱིན་པ་, ཚུལ་ཁྲིམས་, བཟོད་པ་, བརྩོན་འགྲུས་, བསམ་གཏན་, ཤེས་རབ་) is helping you?

16) Did you think about the Buddhist idea of "emptiness" (*nothing exists independently of other causes and conditions*) when you tried to understand the causes and conditions of your design problem? *Please explain why "yes" or "no."*

17) How do you think that your Tibetan identity (values, beliefs, etc) is helping you? (*skip the question if you think that you already answered it*)

18) If you faced difficulties in team work or in your design project:

a. What were those difficulties?

b. How did you overcome those difficulties? *(if applicable)*

19) Did you get help from someone else outside of your group? If "yes", then who?

20) How many meeting did you have on this week? How are you distributing your work?

III. Report writing rules

1) Apply same formatting standard of Report 1

2) Your report should have 3 sections, plus photos:

(Members of the group)

(Project title)

I. Requirements and constraints

II. Answer to questions

III. Copy of your design drawings ☺

Share photos with me: team members working or having meetings

NOTICE: Stop by my guest house if you need guidance. You can also stop me when you see me around in school.

We are here to help you succeed. ☺

IV. Example of Requirements and Constraints

Project Title: Cage to transport TCV school dogs

Requirements:

- Design *must* carry one dog at a time
- Design *must* weigh less than 3 pounds (without a dog)
- Design *must* fit the school driver's car

- Design *must* attract the dog to the cage
- Design *must* avoid harm to dogs
- Design *must* be safe for people – must prevent dogs from biting people

Constraints:

- *Limit* materials to those which are locally available
- Any design expenses need to be limited to less than 50 rupees
- Test the design only with dogs which never have bitten humans

Appendix C Progress report guidelines #3

Third Phase: Selection of best model. Modeling

(DUE DATE: October 1st)

How this work relates to the *real* work of an engineer?

- In this phase, you will
  - (5) Select the best model from different alternative drawings
  - (6) Collect materials for your model
  - (7) Start making your model
  - (8) If you have more time, do an initial testing
- This phase is equivalent to phases of (1) selection of the best design alternative, (2) modeling (prototype), and (3) testing.
- Based on their problem investigation, design requirements, constraints, criteria, design goals, engineers are capable to select materials for their model.

I. Instructions:

12) **Choose the best design** from all of your alternatives ☺
~~13)~~ **Collect materials** for your model ☺
14) **Make your model** based on your drawings, requirements, materials selected, observations, and reflections…. Take notes of your experience when modeling your design. ☺
15) Please, take photos and/or videos when your team is working! We both need this: for your presentation and for my research.
16) Answer questions on Section II.

II. Questions:

21) **Justify why you chose that design** – based on your problem investigation, requirements, and design goal, etc.
    a. *Note*: "Justification" means to give me reasons *why* it is the best design. **See section IV for an example.**
22) What **materials** are you thinking to use? **Justify your decision**.

a. *Hint*: research about the properties of your materials (example: the properties of X type of wood, bamboo, X type of fiber, etc.). Most of your materials must be eco-friendly, locally available, and/or reused.

Be honest answering these questions. Reflect on your experience on this week's (1) team work and (2) design process before answering them: 23) How do you think that Tibetan dialectics is influencing your (1) team work and (2) design process? 24) How do you think that ཕ་རོལ་ཏུ་ཕྱིན་པ་དྲུག་ (སྦྱིན་པ་, ཚུལ་ཁྲིམས་, བཟོད་པ་, བརྩོན་འགྲུས་, བསམ་གཏན་, ཤེས་རབ་) is influencing your (1) team work and (2) design process? *25)* How do you think that the ideas of emptiness, dependent origination, and/or interdependence are influencing your (1) team work and (2) design process? *26)* How do you think that your Tibetan beliefs are influencing (1) team work and (2) design process? *(Example: karma, etc)*

27) **Start making your model. Take photos or videos when your team is making the model.**
28) **If you have more time, please test your model**. Write a paragraph of your observations: do you need to redesign/reconsider anything?
    a. *Example*: "During the process of sticking the aluminum cans to the wood surface we had to reevaluate the base of our design because …"
29) **Why your design is working?** (assuming that it works!) – use physics, engineering concepts, and other sciences knowledge to explain this. You can also help yourself with drawings.
    a. *Example of concepts*: forces, combustion, torque, motion, push/pull, friction, gravity, potential energy, circumference, angle, reaction forces, etc. Design configuration, shapes, sizes, firmness of material, elasticity of materials, etc.
30) Did you get help from someone else outside of your group? If "yes", then who?
31) If you faced difficulties in team work or in your design project:
    a. What were those difficulties?
    b. How did you overcome those difficulties? *(if applicable)*
32) How many meetings did you have on this week? How are you distributing your work?
33) List references that you used:

a. *Example*: (1) Book: "The Way Things Work" by David Macaulay, (2) Web site: www.practicalaction.org

34) **Share photos and/or videos with me**

III. Report writing rules

3) Your report should have 2 sections, plus photos:

(Members of the group)

(Project title)

IV. Answer to questions

V. Copy of refined design drawings

Reminder: Share photos and/or videos with me!: team members working on the project and having a meeting. ☺ You will post photos in your presentation and I will have them for my research too! So it is important!

IV. Example of a justification for the best design

Project Title: Cage to transport TCV school dogs

We decided to select design 2 because it has more space for the dog compared to design 1. There are safety features (reused iron clasps) that we integrated all around the union of the top and bottom of the cage. This is expected to make the cage securer. The safety feature and good space for the dog are to comply with our design requirements: (1) design must not harm the dog and (2) design must be safe for humans – must prevent a dog bite. In addition, our design uses biodegradable materials such as [MATERIAL 1] and [MATERIAL 2]. We researched these materials on [WEB SITE] and we found that [MATERIAL 1] has a higher strength level compared to [MATERIAL 3] that we originally thought we were going to use. …

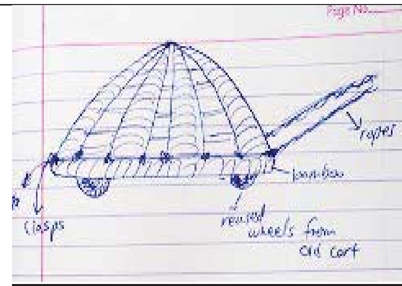


Figure 1: Design 2

Appendix D Electronic presentation guidelines

***Fourth Phase*: Presentation of your design in front of your community ☺**

<u>Due on Monday October 8th:</u>

1. Copy of your [electronic] presentation in a pen drive
2. Finish your design (working model)
3. Photos and/or video or your working model
4. Bring your model to the Multimedia Room (or show me where it is to see it working!)

I will see your electronic and I will give you feedback to support you. This is the same presentation that you will show at the Hall on October 10th (7:00 – 9:00 PM).

I will work with each team separately.

All the 8 groups will present on the same evening of the 10th. **The maximum time for your presentation is 10 minutes.**

<u>Instructions for your electronic presentation:</u>

- These are slides that you must include (except for those marked as optional)
- You can get the information from your reports, but you should refine your text
- See the brackets [ ] for the content that you need to add in your presentation

Slide	Optional?	Slide content
1		**Project Title:** **Team members:** **Course title:** Introduction to Engineering
2		**Problem statement:** [One paragraph – report #1] **Branch of engineering:** [Write the branch of engineering that your project fits in – civil, mechanical, electrical, etc…] [At least one photo related to your problem]
3		**Interview to investigate about the problem:** [Summary of your interview – report #1] [At least one photo related to your interview (if you have it!)]
4		**Requirements of our design:** [Get them from report #2] [… you are free to post more photos if you wish so]
5		**Constraints of our design**: [Get them from report #2] [… you are free to post more photos if you wish so]
6		**Design drawing(s):** [Take a photo of your best drawing(s) – put the photo in this slide] [Write a paragraph explaining the parts of your design] [Tell the audience what are the features of your design – the uniqueness of your design! ☺]
7		**Working model of our design:** [Take a photo of your working model – put the photo in this slide] [Paragraph that explains why your design works – using physics / math / other sciences knowledge]
8		**Why our design is a "sustainable design"?** [Write one paragraph explaining why is a sustainable design] *Hint*: review presentation 3.1: Sustainability *Hint*: eco-friendly, reused materials, biodegradable

		materials, low energy consumption, etc. [… you can post more photos if you wish – related to your model or your team working]
9		**What *new* experiences we had while we were making our model?** [Write a paragraph of what new things you learned while you were making your model ☺] Examples: “we went to VTC and we worked with a welding machine because … ,“ “We learned how metals are cut …,” “we had a hands-on experience in the carpentry department at VTC…,” “we learned that we could use _____ in order to move …,” “we learned that X wood is good for….”
10		**How the six virtues helped us in our project?** [Write and say this slide in Tibetan BUT I need a translation!] [Write a paragraph that describes how do you think that generosity, patience, effort, ethics, concentration, and wisdom helped you to accomplish your project] [You can put photos of your team working – if you have them!]
11	OPTION AL	**How Tibetan dialectics helped us in our project?** [Write and say this slide in Tibetan BUT I need a translation!] [Write a paragraph that describes how Tibetan dialectics helped you to identify, understand, and design a solution for the problem]
12	OPTION AL	**Who helped us in our project?** [Acknowledge the people who helped you – if any] [do not include Marisol]
13		**References** [List your Internet, books, magazine, etc..]
14	OPTION AL	**[Closing slide]**

Appendix E Example of an engineering design project in Alampoondi, Tamil Nadu (presented in lesson 1.2)

Example of an engineering design project: Solar power for Alampoondi, Tamil Nadu

(Quotes are from source: http://www.liteecases.com/lcm/catalog/case_stiudies/0/solarpowrerural/58)

How this information might help you?

- You can have a better picture of the *steps that engineers took to design a solution for a community problem*.
- In this case, the engineering students were doing a **multidisciplinary work**: *civil, mechanical, electrical, and sustainable engineering*.
- Do you see yourself doing one or more of the following steps? Which ones? ☺

Steps that engineers took to design a solution:

1. **Engineers investigated about the site and community**

"Alampoondi is a rural village located at 12.25 degrees North Latitude 79.42 degrees East Longitude in the heart of Tamil Nadu."

"Alampoondi has a population slightly over 1,000 people. Most of these people rely on sugarcane and rice agriculture for their daily income. Many villagers seek work from the Gandhi Rural Rehabilitation Center **(GRRC)** where organic cotton textiles are produced."

Potentials of solar-power technology in this village:

"(…) solar-powered pumps could be used to supply the villagers with clean, fresh water from deep bore wells. The village health clinics could benefit from solar energy by using lights to treat patients at night and refrigerators to store vaccines. Primary schools could illuminate classrooms that are being heavily used in the evenings for adult education and as places for children to come and do their lessons."

2. **Engineers wrote a problem statement (description). They supported their claims with previous research in statistics, social sciences, and natural sciences:**

"An estimated 750 million people in India live in rural areas that have little to no power. This group constitutes
seventy percent (70%) of the country's population. Of this group, forty-five percent (45%) are hooked up to a
power grid and endure daily power failures. Therefore, many rural regions in India have to rely on polluting

kerosene lamps and household stoves to meet lighting needs. Those without grid access must often walk long
distances to buy a few liters of expensive kerosene."

"The Gandhi Rural Rehabilitation Center (GRRC) was selected as a **test site** in order to transform the quality of life of residents of that center. Because the GRRC is central to many villages, the result from this experiment has the ability to be replicated more widely. (…) The **outcome** of this project is to provide solar energy to the center as well as educate villagers on the routine maintenance required for upkeep of solar technology.

"Based on the power consumption statistics of GRRC, the team decided to install a solar power system in
order to electrify the following devices:"

- "Electrifying five (5) sewing machines – 62 Watts per machine"
  Note: Watts is a measurement of electrical power.
- "A water pumping system that is powered by a 3/2 hp (approximately 1119 W) electric motor"
  Note: Hp is "horsepower." It is another unit of measurement of power. It is used to measure the power of turbines, machinery, and other motors. In this case, the electric motor of a water pumping system"

3. **Engineers selected technologies, shared ideas, and did mathematical calculations.**

In summary, these were <u>all</u> the steps that they did to implement the design! ☺
Note: "Implement" means to put into action what you designed
Note: PV = photovoltaics = method to convert solar radiation into electricity

- **Step 1:** Visit the village
- **Step 2:** Assess the need and requirement for the solar panel system
- **Step 3:** Estimate the load requirements and number of hours of usage
- **Step 4:** Study and implemented energy efficiency ways
- **Step 5:** Size the PV array (solar panel), battery bank, loads, wires and switches
- **Step 6:** Draw the technical specifications of other items like the charge controller, converter, inverter and disconnect switches
- **Step 7:** Study the installation (roof or land) and wiring requirements
- **Step 8:** Study the system integration and design the PV Systems
- **Step 9:** Prepare the bill of materials and cost estimates
- **Step 10:** Send the enquires to potential suppliers
- **Step 11:** Receive quotes and technically evaluate them
- **Step 12:** Select the suppliers and place the orders
- **Step 13:** Receive the components, materials and subsystems

- **Step 14:** Test them to ensure their quality and accept them
- **Step 15:** Install and commission the PV Systems
- **Step 16:** Take performance measurements and document them
- **Step 17:** Prepare the operation and maintenance manuals
- **Step 18:** Training for the users
- **Step 19:** Select and train personnel on routine operation and maintenance and on troubleshooting of simple failures
- **Step 20:** Conduct the field evaluation of systems at the site(s)
- **Step 21:** Study any field failures and develop performance improvements.
- **Step 22:** Get the feedback from the users
- **Step 23:** Modify the System Design for performance enhancement, better reliability, and decreased cost.
- **Step 24:** Replicate the projects at other potential sites
- **Step 25:** Prepare the technical, techno-economic and socio-economic project reports

Appendix F Example of an engineering project for a village in Senegal, Africa (presented in lesson 1.2)

Real example of an engineering project: Grain crusher for a village in Senegal, Africa

Adapted from:

Lucena, J., Schneider, J., & Leydens, J. A. (2010). Why design for industry will not work as design for community. *Engineering and Sustainable Community Development*, *5*(1), 55–83. doi:10.2200/S00247ED1V01Y201001ETS011

How this exercise might help you?

- This is a real example of an engineering design project that was accomplished by students who participated in a global engineering project. Due to *globalization*, engineers currently need to develop skills to be competent in the globalized engineering workforce.
- Engineers might participate in projects with other engineers from different parts of the world and cultures. They might need to design solutions for peoples of different cultures. *Critical thinking* becomes an important "tool" for the engineer to design better solutions for people.

Small group discussion exercise: Why critical thinking is important in engineering?

Instructions:

We are going to go outside of the classroom and do this exercise in small groups. 7 groups of 4 and 1 group of 3 students will be fine. ☺

(1) In your group, read the engineering project description (in a box) and discuss it. After each paragraph you will find some critical thinking questions that the authors asked. **Your job:**

- **Imagine that you are an engineering student. Ask the following in your group:**

1. What other questions comes to your mind when you read the project information?
2. What other information you should know to design a better solution?
3. What would you have done differently?

(2) In the paper that I gave you, **write a mini-report of your discussion**. 1-3 paragraphs is fine. Return it to me after the exercise. **Remember to write the names of the people in your group**.

** Raise your hand if you need help **

I. *Problem Description***:** (…) One of the needs [of this village in Senegal] is an efficient and inexpensive way to crush and dehusk grain. The grain crusher project arose from an Engineers Without Borders trip to Senegal. They said that the people there do have a grain crusher, but some cannot afford it due to the cost of diesel, which is the fuel used to power the crusher. Also, the hand method of mortar and pestal is very time consuming and hard on the body…

- How these engineering students knew what this community *needed*?

II. *Description of the solution: (engineering students decided to search for designs of preexisting grain grinders. They looked for a grinder produced in Uganda)* The Ewing III grinder is produced in a manufacturing plant in Uganda (…). Discovering the Ewing III grinder allowed us to shift our focus from designing a complete grinder to developing improved methods to power an existing grinder. We attempted to contact CTI in an attempt to acquire a Ewing III but never received a response. As an alternative, we selected the Country Living Grain Mill as a comparable substitute to the Ewing III grinder.

- Can a grinder produced in Uganda or the United States be appropriate in Senegal?

.

III. *Description of the solution (cont.):* For powering a grain crusher, a device is needed to convert human power to mechanical power for the grinder. Designs included pedal bicycles modified with a chain or drive belt used to turn a crank on a personal, kitchen type grinder. *The group decided that a bicycle stand for an existing bicycle would be the best idea for the scope of the project***.** A bicycle stand was constructed with intentions to be attached to a pre-existing grinder. Of critical importance to the design was a wide range of adjustability so that the final product could fit a variety of bicycles. The stand would need to fit bikes with tire diameters ranging from 20 inches to 26 inches, and also with varying rear axle widths. The design also had to allow for adjustment to the tension in the drive belt, so it was decided that the grain crusher's location would be adjustable to provide such tension. The only fixed components would be the center drive axle and its supports. (…)

- How did the engineers know that the potential users would want to pedal a bike as a source of energy for the grinder? Who did they have in mind when selecting a bike? (children, elders, women, etc.)

IV. *Testing phase*: This design was tested for (1) how long it would take to grind different types of grain and roughly (2) how much energy was required to grind each type of grain. A simple test was done by tying weights to a string and then tying the string to the shaft of the crusher. The maximum weight that we could lift at a replicable rotational speed of about 1888 RPM was 44.85 N. (…)

- Was the design tested with people from the community? (the people who will actually use the technology)

V. *Implementing the design in the community:* They found that there is already an existing grain crusher that can be used, but the cost of the diesel to run the crusher prohibits some of the communities from using the grain crusher. Also, the women of the community are the ones who crush the grain everyday, and to do so they wake up around 4:30 am to produce enough grain for the day.

- If a key problem with the existing grinder is the cost of diesel, could engineers envision simpler *economic solutions* (e.g., subsidies or increased efficiency in diesel transportation, etc) instead of a new technology?

VI. *Implementing the design in the community AND report of findings:* (…) There were several major aspects that were observed. The first is that when adjusted properly, the crusher also removed the skin of the lentils very well. Also, not many of them wanted to sit on the seat and pedal, especially the women, because they did not want their clothes being caught up in the chain. Instead, they sat down behind the crusher and pedaled by hand. (…) Once the trial was done, a roundtable discussion was had in order to receive feedback and suggestions to improve upon the design. They said that when they wanted the grain fine, it took too long so they wanted larger grinding plates to improve capacity. They also said that the grain tended to get caught up in the plates and just repeatedly cycling around, so they suggested making the plates horizontally oriented, in hopes of expelling the crushed grain faster.

- How the students learned about the local processes of dehusking?
- How could a “roundtable discussion” yield good information when there has not been enough time or opportunities for the community to develop *trust* with the engineering students?

Appendix G Special step-by-step guideline for team 8

Feedback before electronic presentation (October 3, 2012)

Instructions:

1) <u>Follow the guidelines for [electronic] presentation</u>
    a. **Take cool photos of your work. You will add them in your presentation.**
    b. **Drawings of your design are needed … even more that you will not be able to take a "use me" to the Hall on October 10th ☺ . You need to help the audience visualize what is your design (solution to the problem).**
2) <u>Please do the following to investigate your problem. When you read the guidelines, you will see that it is needed in your presentation:</u>
    a. <u>PROBLEM INVESTIGATION:</u>
        i. Do a quick interview to someone who has *really* expressed that the rusty "use me's" is a problem in the school – this is part of your problem investigation
        ii. Search for **scientific explanation on why some metals get corroded**
        iii. **Your key chemistry and physics concept: *corrosion*, *rust*. What are the differences?**

            http://science.howstuffworks.com/question445.htm

            http://www.corrosion-doctors.org/Corrosion-History/Rusting.htm
        iv. Search for engineering science information on **surface treatments for metals** – to prevent corrosion
            1. Note: Surface treatments of metals are part of **tertiary manufacturing processes** – revise Lesson 2.1
        v. Search for **common repairing techniques for rusty metals**
            1. Note: <u>Do not use only paint. Try to design a way to prevent even more rust on the metal.</u>
        vi. Search for **metals which will not corrode: why these particular metals will not corrode?**
            1. Try to find that type of metal to fix the bottom of the "use me."
                a. If not: what other alternatives do you have?
        vii. Why this particular metal is rusted?

1. Climate conditions of this region of India, quality of metal, etc.

b. What materials will you plan to use? How are you going to get your materials?
c. Select only one “use me” – the one that is used the most by the school
d. *Sustainable design*: reuse materials, biodegradable materials, low energy consumption, etc. Review Lesson 3.1 and 3.2 for more information if needed.

Appendix H Engineering design project evaluation rubric

Engineering Design Project Evaluation Rubric

Team: __________
Project Team Members: ________________ ________________ ________________
________________ ________________

	Excellent			Good			Adequate			Low passing			
	(12)	(11)	(10)	(9)	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)	(0)
Accomplishments and Overall Quality: 1) Submitted the three project reports (3) 2) Presented their project (3) 3) Followed project instructions and answered guidelines questions (3) 4) Clear understanding of the design problem and constraints(requirements) (3)													
Reflective/Critical Thinking: 1) Team was able to reflect on how their values, beliefs, and identity as a Tibetan influenced their project and team work (5) 2) Project reflected consideration of social, ethical, environmental, and economic aspects (4) 3) Decisions were taken based on appropriate investigation (e.g., online references, books, interview with people, etc) (3)													
Teamwork/Leadership: 1) Team worked together to accomplish project and individual goals (4) 2) Appropriate division of tasks (4) 3) Dedication to meeting stated deadlines (4)													
Engineering: 1) Team was able to explain in terms of engineering concepts (applied physics, scientific, or mathematics knowledge) how their design works (12)													
Sustainability: 1) Team was able to explain why their design can be considered sustainable (12)													

Comments:

Final grade: /60

Last edited 11/7/2012

Appendix I Fieldnotes reflective questions template

Date:

Write a narrative based on these questions (not limited to them). Remember the research questions[81]: *(1) How do Buddhism and Tibetan culture influence the engineering thinking of Tibetan students? (2) What are the institutional processes of change that I undertook with the Tibetan community in exile to develop and implement culturally responsive engineering education?*

General questions:

1) In what activities did you participate today? Give a brief explanation about them.
2) What people did you meet today? What roles in the community do they have?
3) Any other important information needed to know about them?

Mapping to culture:

4) Did you learn more about one or more Tibetan culture and Buddhism activity today? (yes/no). If yes, for each one, provide the following:
    - What did you learn? (if any)
    - Who facilitated the knowledge? What was the resource? (if any)
    - If you scanned, took a photo or a video, please, attach it to the entry. Any other media, please, attach it to the journal entry.

Mapping to Mezirow's theory:

5) Did something work out well in your interactions with Tibetan educators and/or students? How did they react? Does it have a relationship with a past event? Describe. (self-reflections on the interactions with the people)

[81] Originally, the research questions were asked in this way, but they were slightly changed during fieldwork to reflect the context of my research study and what I was learning.

6) Did something striking (negative) happen (e.g., teaching, interacting with people). Is it related to a previous event? Describe. (self-reflections on the interactions with the people)
7) What assumptions about Tibetan educators, students, education, institutional processes did you start to reflect or continue reflect upon?
8) Any plan of action for tomorrow based on what I reflected today? (e.g., readings about X, reflections about X discussion)
9) Could you give recommendations to educators/researchers developing similar courses under a culturally responsive approach, based on what you learned today?

Appendix J Class fieldnotes guide

Date:
Time:
Lesson:
Note:

Mapping to Mezirow's theory:

1) Did your students react to a certain type of topic? How did they react? What did they say? Please explain the context and the participants. Use identifiers instead of names.
2) What class reflections did they share with your today? What type of reflection could that be categorize in? (content: *what*, process: *how*, premises: *why*).
3) Was the reflection (way of learning) based on (1) previous knowledge (elaborating on meaning perspectives), (2) probing on new meaning perspectives, (3) attempting to transform points of view, or (4) transforming assumptions.
    - What evidence (e.g., observations) do you have to support your claim?
4) Were they seeking for more instrumental, dialogic, or self-reflective learning?
    - What evidence (e.g., observations) do you have to support your claim?
5) Can you identify the meaning perspective that they were trying to reflect upon (if any):

- Type of meaning perspective: ______________ (epistemic, cultural, psychological, philosophical, aestetic, sociology)
    - Belief:
    - Feeling:
    - Knowledge:
    - Assumptions they have:
    - Phenomena:

6) Can you identify if their reflections are related to one of the ten phases of transformative learning? Please describe. What evidence (e.g., observations) do you have to support your claim?

Mapping to culturally responsive pedagogy:

7) In what ways Tibetan culture, identity, *and* language influenced their engineering thinking and engineering-related discussions? Please describe.
    - What evidence (e.g., observations) do you have to support your claim?
8) In what ways Tibetan Buddhism influenced their engineering thinking and engineering-related discussions? Please describe.
    - What evidence (e.g., observations) do you have to support your claim?

Reflection on what steps do tomorrow based on today's experiences:

9) What plan for tomorrow do you have based on what you identified today in your students' reflections (learning process)?

Appendix K Semi-structured interview guide for Tibetan educators, school administrators, curriculum experts, technical experts, or cultural experts

Date: ___________________

Location: __________________________

Case number: _____________________

Give copy of the course outline (or syllabus) and the final project to the interviewee.

General questions:

1) What is your name?: _______________________ [voluntary]
2) What is your gender (female, male): __________________
3) What is your age? ___________ [voluntary]
4) How do you describe yourself in terms of ethnic identity (e.g., Tibetan, Tibetan-Indian, Nepalese, etcetera): ________________________
5) Where you were born? (e.g., Tibet, X province of China, India, Nepal, Bhutan, etcetera) _____________________________ [voluntary]
6) Since what year you have been in India? ______________________ [voluntary]
7) What is your job title / role in the Tibetan community? *Circle one or more options. Fill in the blank if other title:*

   Educator, student, school administrator, teacher assistant, monastic, children caretaker, carpenter, artist, sculptor, engineer, architect, **other:** _______________________________)

About STEM courses:

8) Have you taught STEM courses? (yes/no)
   - If yes:
     - What are your difficulties in **teaching** engineering, technology, science, and mathematics to Tibetans?
       - (if applicable) What recommendations would you give to solve these problems? What would you like to see solved?

- What do you think are the difficulties of the students in learning engineering, technology, science, and mathematics to Tibetans?
  - (if applicable) What recommendations would you give to solve these problems? What would you like to see solved?
- How did you become a STEM educator in Tibetan schools?
  - What kind of training did you receive in STEM? Where?

About the Tibetan educational policy in exile:

9) Tell me more about the Tibetan educational policy in exile. Are you familiar with it?
10) How do you make sure that you are following the guidelines of the Tibetan educational policy in exile?
11) Is it implemented in all the schools?

About the course content:

12) Does [the school] have rules or guidelines to develop and teach courses? Could you inform me more about them?
13) I have outlined possible course topics, what do you think of them?
    - o Do you think that the course content will best meet the needs for Tibetan students? (yes / no / possibly)
      - How would you change it to best meet the needs of Tibetan students?
14) What would you like to see in the course?
    - o What would you *not* like to see?
    - o Any information that is not supposed to be taught in class?
    - o Any information that is not supposed to be published?
15) What do you think of those areas where Tibetan culture and Buddhism will be presented?
    - o How would you ensure that these sensitive aspects will be best respected?

If pointing to a specific content in one of the course lessons

10) Is the description of the object accurate?
- o In terms of:
  - How did it work?

- How it was made?
- How it was used?
- Who used it? (e.g., certain social class, gender, status – if any)
- Who made it?
- From what region of Tibet does it come from – if any
- Is the description related to Tibetan culture and Buddhism accurate in your view?
- Any concepts in Tibetan language?

11) How would you describe it more accurate?

12) Any description that is not supposed to be taught in class?

13) Any description that is not supposed to be published in a dissertation or academic paper?

About the course project:

16) What do you think about the course project?
    - How would you make it different?
    - Do you think that the students will have the means and capacity to accomplish the course project?
        - How may we modify it to meet the students' needs and capacity?
    - Do you think that Tibetan culture and Buddhism will influence the students' work? (yes / no / possibly)
        - How? (In what ways?)

About culture, Buddhism, and learning:

17) How do you think that *Tibetan Buddhism influence in the <u>learning</u> process of your students* who are taking mathematics, science, technology-engineering? (probe each separately)? Can you give me an example? *(probe also with the word "<u>thinking</u>")*

18) How about Tibetan culture? In what ways do you think that *Tibetan culture influence in the learning process of Tibetan students*? Can you give me an example?

- What about particularly in science, mathematics, engineering-technology

19) How about *Tibetan language*? How do you think it influences in learning and teaching mathematics, science, technology, and engineering?

20) How about *in presenting a scientific problem to the students*? How does Tibetan language influence? What about Tibetan culture? And Tibetan Buddhism? (probe each separately)

About Tibetan mathematics[82]*:*

In the Tibetan educational policy in exile, they speak that Tibetan mathematics will be integrated in the school curriculum:

> "(…) adequate study of modern mathematics and an elementary introduction to
> traditional Tibetan mathematics shall be included in the school curriculum."
>
> (Source: http://sherig.org/publications/eduPolicy/bep_english.pdf, p. 8)

21) Is it related to Tibetan ways to measure things?

22) Are they related to the mathematics that are taught in the monasteries? For example, Tibetan arts (thangka paintings), etc.

23) Or are they related to specific number system used in Tibet?

[82] When I asked about "Tibetan mathematics" and I presented the information to the teachers I interviewed, they did not know about the document (Tibetan educational policy in exile). After they read the sentence, some teachers speculated that it is a translation error in the document. That it should say "…introduction to mathematics in Tibetan…" rather than "…introduction to traditional Tibetan mathematics…" Some other teachers thought that they are referring to the policy that requires teachers in *elementary* school to teach mathematics in Tibetan. Yet even another Tibetan teacher told me that he was confused when he read "Tibetan mathematics" because he only knows about "mathematics," not different types of mathematics.

24) Can you refer me to the person who knows more about it?

25) Were there special measurement units to create the buildings and bridges? What do you know about them?
    - Can you refer (introduce me) to an Elder in the community who knows more about it?

26) Do you know of stories that tell how Tibetan people in the past would solve infrastructure, agricultural, or "engineering-related" problems in their community?
    - Can you refer me to someone else who knows more about it?

27) What are the words in Tibetan that best describe engineering?

If he or she is a school administrator, ask this other question:

Can I observe one or more classes taught at [the school] to see the teaching ways of local teachers? (to see if I need to consider other methods in my ways of teaching)

- Do you know of a high school nearby where I can observe a science, technology, or mathematics class?

Closings:

28) Do you know of other Tibetan educators who would be interested in giving their suggestions on the course topics? Could you refer me to him or her?

    ____

    ____

    ____

Thanks the participants: *Tu-jii-cheh*. Give compensation in cash.

Appendix L Semi-structured interview guide: Focus group for Tibetan educators, school administrators, curriculum experts, technical experts, and cultural experts

Date: ____________________

Location: ___________________________

Each member of the focus group will have a copy of the course outline (or syllabus), of the description of the final project, and of the following general questions:

General questions:

1) What is your name?: ________________________ [voluntary]
2) What is your gender (female, male): __________________
3) What is your age? ___________ [voluntary]
4) How do you describe yourself in terms of ethnic identity (e.g., Tibetan, Tibetan-Indian, Nepalese, etcetera): ________________________
5) Where you were born? (e.g., Tibet, X province of China, India, Nepal, Bhutan, etcetera) _____________________________ [voluntary]
6) Since what year you have been in India? ______________________ [voluntary]
7) What is your job title / role in the Tibetan community? *Circle one or more options. Fill in the blank if other title:*

   Educator, student, school administrator, teacher assistant, monastic, children caretaker, carpenter, artist, sculptor, engineer, architect, **other:** ________________________________)

(For researcher's use only) *Case number:* ___________________

Tashi delek. [Introduce yourself].

About STEM courses:

8) Have you taught STEM courses? (yes/no)
    - If yes:
        - What are your difficulties in **teaching** engineering, technology, science, and mathematics to Tibetans?
            - (if applicable) What recommendations would you give to solve these problems? What would you like to see solved?
        - What do you think are the difficulties of the students in learning engineering, technology, science, and mathematics to Tibetans?
            - (if applicable) What recommendations would you give to solve these problems? What would you like to see solved?
        - How did you become a STEM educator in Tibetan schools?
            - What kind of training did you receive in STEM? Where?

About the Tibetan educational policy in exile:

9) Tell me more about the Tibetan educational policy in exile. Are you familiar with it?
10) How do you make sure that you are following the guidelines of the Tibetan educational policy in exile?
11) Is it implemented in all the schools?

About the course content:

12) Does [the school] have rules or guidelines to develop and teach courses? Could you inform me more about them?
13) I have outlined possible course topics, what do you think of them?
    - Do you think that the course content will best meet the needs for Tibetan students? (yes / no / possibly)
        - How would you change it to best meet the needs of Tibetan students?

14) What would you like to see in the course?
    - What would you *not* like to see?
    - Any information that is not supposed to be taught in class?
    - Any information that is not supposed to be published?
15) What do you think of those areas where Tibetan culture and Buddhism will be presented?
    - How would you ensure that these sensitive aspects will be best respected?

If pointing to a specific content in one of the course lessons

14) Is the description of the object accurate?

    - In terms of:
        - How did it work?
        - How it was made?
        - How it was used?
        - Who used it? (e.g., certain social class, gender, status – if any)
        - Who made it?
        - From what region of Tibet does it come from – if any
        - Is the description related to Tibetan culture and Buddhism accurate in your view?
        - Any concepts in Tibetan language?

15) How would you describe it more accurate?
16) Any description that is not supposed to be taught in class?
17) Any description that is not supposed to be published in a dissertation or academic paper?

About the course project:

16) What do you think about the course project?
    - How would you make it different?

- Do you think that the students will have the means and capacity to accomplish the course project?
    - How may we modify it to meet the students' needs and capacity?
- Do you think that Tibetan culture and Buddhism will influence the students' work? (yes / no / possibly)
    - How? (In what ways?)

About culture, Buddhism, and learning:

17) How do you think that *Tibetan Buddhism influence in the learning process of your students* who are taking mathematics, science, technology-engineering? (probe each separately)? Can you give me an example? *(probe also with the word "thinking")*

18) How about Tibetan culture? In what ways do you think that *Tibetan culture influence in the learning process of Tibetan students*? Can you give me an example?
- What about particularly in science, mathematics, engineering-technology

19) How about *Tibetan language*? How do you think it influences in learning and teaching mathematics, science, technology, and engineering?

20) How about *in presenting a scientific problem to the students*? How does Tibetan language influence? What about Tibetan culture? And Tibetan Buddhism? (probe each separately)

About Tibetan mathematics:

In the Tibetan educational policy in exile, they speak that Tibetan mathematics will be integrated in the school curriculum:

"(…) adequate study of modern mathematics and an elementary introduction to traditional Tibetan mathematics shall be included in the school curriculum."

(Source: http://sherig.org/publications/eduPolicy/bep_english.pdf, p. 8)

21) Is it related to Tibetan ways to measure things?

22) Are they related to the mathematics that are taught in the monasteries? For example, Tibetan arts (thangka paintings), etc.

23) Or are they related to specific number system used in Tibet?

24) Can you refer me to the person who knows more about it?

25) Were there special measurement units to create the buildings and bridges? What do you know about them?
    - Can you refer (introduce me) to an Elder in the community who knows more about it?

26) Do you know of stories that tell how Tibetan people in the past would solve infrastructure, agricultural, or "engineering-related" problems in their community?
    - Can you refer me to someone else who knows more about it?

27) What are the words in Tibetan that best describe engineering?

Closings:

28) Do you know of other Tibetan educators who would be interested in giving their suggestions on the course topics? Could you refer me to him or her?

    ____

    ____

Thanks the participants: *Tu-jii-cheh*. Give compensation in cash.

Appendix M Semi-structured interview guide for non-Tibetan community members

Date: ___________________

Location: ____

These are some questions about the education system of the Tibetan community. You can skip those questions that you do not know the answer or feel uncomfortable.

General questions:

1) What is your name?: _______________________ [voluntary]
2) What is your gender (male, female): __________________
3) What is your age? ___________
4) How do you describe yourself in terms of national or ethnic identity (e.g., American, Hispanic-American, European, etc.) ________________________
5) Where you were born? (e.g., England, Germany, United States, etcetera) _____________________________ [voluntary]
6) Since what year you have been in India? ______________________ [voluntary]
7) What is your job title / role in the Tibetan community?:

   Circle one or more options. Fill in the blank if "other title:"

   Educator, student, school administrator, teacher assistant, monastic, children caretaker, carpenter, artist, sculptor, engineer, architect, ***other:*** *_______________________________)*

Main queries

1) What Tibetan high schools and colleges are open in the summer time? Is the summer time a good session to give classes? Why?
   a. What is the closest Tibetan Children's Village or Tibetan school in the community where I can recruit students or promote my course?
2) How many high school students stay in the summer time in school?
   a. How about within the community? (Approx.)

3) How many adults who can potentially take the class stay in the summer time in the community area?
4) What are the roles of the other people stay in the summer time? (probe for: elders, educators, etc.)
5) I have structured an introduction to engineering course for 1 hour, two days a week (show the outline and course project). Do you think that students will be available to be available for the class? Why?
    a. How would you structure it and why (hours, days).
    b. What type of students would be more likely to be in those hours?
    c. Do they work during the summer time?
        i. About what percent of them (between 18 and 25) have children?
    d. What would be the best hours and days for them to take the course?
6) Do you think that some of the high school and adult students have communicated through e-mails with their teachers? What age group more likely will do so?
7) What other audience do you think would be more suitable for the class? (e.g., to teachers – give the class to train teachers about what is engineering)
8) What kind of resources do the school(s) have? (e.g., computers, chalkboards, etc)
9) What kind of hurdles do you expect the student will have in learning science, technology, and engineering information?
    a. In terms of culture, socio-historical struggles, educational background.

About high schools and Tibetan Children's Village

10) What type of activities they do in the summer time? (educators and high school students)
    a. How many hours? What days of the week?
11) (Show her/him my course outline) Do you think that topics like these might fit better within the schedule of a summer camp (if they already have one)?
12) Do you have the contact details of the person in charge of the school or summer camp? Would it be possible to contact him/her? (e.g., email, mailing address, phone, Skype)

About educators and high school students

13) In your view, what is the real capacity of English that high school students have?

   a. Writing
   b. Speaking
   c. Reading
   d. Listening - understanding

Appendix N Revision at the field: Semi-structured interview guide for Tibetan engineers

Tibetan Engineers Semi-structured interview guide (rev. 8/31/2012)

Date: ____________________

Location: ___________________________

Case number: ______________________

Give copy of the course outline (or syllabus) and the final project to the interviewee.

General questions:

29) What is your name?: ________________________ [voluntary]
30) What is your gender (female, male): ___________________
31) What is your age? ___________ [voluntary]
32) How do you describe yourself in terms of ethnic identity (e.g., Tibetan, Tibetan-Indian, Nepalese, etcetera): _________________________
33) Where you were born? (e.g., Tibet, X province of China, India, Nepal, Bhutan, etcetera) ______________________________ [voluntary]
34) Since what year you have been in India? _______________________ [voluntary]
35) What is your job title / role in the Tibetan community? *Circle one or more options. Fill in the blank if other title:*

    Educator, student, school administrator, teacher assistant, monastic, children caretaker, carpenter, artist, sculptor, engineer, architect, **other:** ________________________________)

36) Your educational background:
37) In a univ. in India?:
38) How did you connect with TCV and became a teacher (or admin)?: (IF APPLICABLE)

When you were in high school

When you were in high school, did you feel that engineering was something for boys only?

Do you remember if there were activities in high school that resembled engineering practice? (e.g., team work, solving problems with local available resources, etc)

How did you learn about engineering when you were in high school? For example, what books, classes, tv shows, magazines, counselor, librarian, etc

Why did you choose to study engineering? What were the reasons? Did you pass the test of DoE – reserved seats?

Did you choose civil engineering because of a personal passion to it, or for any other reason?
Who helped you to choose or get admission in an engineering university when you were in college?

What would you have liked to learn in high school about engineering? What opportunities would you have liked to have to understand better what is engineering?

College years
What challenges/difficulties did you face as an engineering student in _____ institution?

What about your transition period? Did you get mentoring from other people (Tibetans)? Who helped you in this transition from Tibetan school to college?

Do you also think that these challenges are also faced by female Tibetans who study engineering?

In what ways do you think that Tibetan culture (beliefs, ways of thinking) and Buddhism were influential for you to identify, understand, and solve problems related to engineering? You can provide an example

Do you remember if in college you were taught topics about sustainable engineering and energy alternatives?

Engineering practice (if applicable)

How Tibetan dialectics have helped you in your engineering thinking? (identifying, understanding, and solving a problem)

In what ways do you think that Tibetan culture (beliefs, ways of thinking) and Buddhism were influential for you to identify, understand, and solve problems related to engineering? You can provide an example

How the six paramitras (generosity, ethics, patience, perseverance, concentration, wisdom) have helped you in your engineering practice? You can give examples of situations/

Attempts teaching / current problems in school related to engineering education

Why do you think that there are not so many Tibetan engineers? Apart from lack of financial stability.

What knowledge and information about engineering do you think that students need the most to consider studying engineering?

What other school do you think that would benefit from a course like this?
If you were to teach the class, what would you teach the students?

What challenges do you have when you are trying to explain engineering-related knowledge to other Tibetans without this knowledge in INFORMAL LEARNING SETTINGS?
What have been successful cases of teaching engineering-related knowledge in INFORMAL LEARNING SETTINGS?

How important do you think that the role of the counselor is when a student is interested in engineering? Do you think that they are needing more knowledge about eng? How could this knowledge be imparted?

What are the issues that impede (prevent) students to

a) Getting admissions to engineering schools in India or abroad
b) Transition from TCV to college
c) Continue in engineering up to graduation (retention issues)
d) Obtaining an engineering-related job in India or abroad

<u>Tibetan culture's influence</u>

Do you think that the way of valuing/respecting teachers in Tibetan Buddhism influence in the ways of valuing/respecting teachers in non-monastic schools (such as TCV)? **In what other ways do you think that the influence of monastic education and teaching still is influencing in lay people's schools?**

In what ways do you think that Tibetan culture (beliefs, ways of thinking) and Buddhism influence in students' ways to identify, analyze, and solve problems? – engineering thinking

In what ways do you think that Tibetan culture and Buddhism influence in the way that students manage team work?

How do you define engineering?

What words in Tibetan best describe engineering?

Did you ever learn about Tibetan ways to measure things? – in rural Tibet – Special measurements and proportions.

Closings:

What advise would you give to Westerners who are developing courses for Tibetans or who are teaching to Tibetans? – related to technology, engineering, science, mathematics

What are the problems that schools face when Westerners come to Tibetan schools to do research or teach courses?

Do you know of Tibetan engineers or administrators who would be interested in participating in the study?

Thanks the participants: Tu-jii-cheh. Give compensation in cash.

Appendix O Template to research Tibetan ways of solving a problem

(I will research three traditional ways to solve a problem to give as class examples)

Date: ___________________

Location: ____

General description:

1) What they needed to solve? What is the problem?
2) Was a tool or artifact involved to solve the problem? (yes/no)
3) Was a structure or architecture constructed to solve the problem? (yes/no)
4) For each artifact or structure, please, describe the steps to construct it

Tibetan Buddhism and culture:

5) Did the way of solving a problem was influenced by Buddhism and Tibetan culture?
6) Did the way of designing an artifact/structure have meanings in Buddhism and Tibetan culture? Please list and describe them.
7) What Tibetan symbols, patterns were painted on the artifact?
8) Do they have a meaning in Tibetan culture and Buddhism?
9) What important terminology do I need to know in Tibetan language?

Photographic/scanned evidence:

10) Is there at least one picture? May the picture be scanned?
11) Who is the owner of the picture? Or what is the source where it was published? (If there's no picture, but you have the artifact, seek permission to take a photo or scan the source. Go to Appendix __)

Appendix P Pre-course questionnaire for students

Thanks for your interest in the Introduction to Engineering short course! ☺. These are questions to help me understand your knowledge in engineering and sustainability.

Your answers will be part of my Engineering Education doctoral research. They will **not** be used to grade you or filter you out of the course. **Your answers will be confidential.**

If you do not understand a question, please, let me know to help you.

If you need more paper to answer the questions, let me know.

I. Demographics

Name: ____

Gender (male or female): ________________________

Age: _____________

Grade (11 or 12): _________

Are you a Tibetan? (yes/no): ___________

In what country you were born? ______________________

If you were born in Tibet, since what year you have been in India?: _______________

Are you planning to study a degree in science, technology, engineering, or mathematics:

(yes / no / unsure)______________

Why? ____

What field of study specifically? (if known):

____

Would you consider to study a science, technology, engineering, or mathematics degree <u>in the West</u>? **(yes / no / unsure)** ______________

Why? ____

II. Main questions

These are general questions about engineering, engineers, sustainability, and sustainable engineering. Please, answer them the best that you can:

1) How do you define "engineering"?

2) Do you think that the understanding of "engineering" is different in India and Tibet? **(yes / no / unsure)**

   How it is different? (if "yes"):

3) How do you define an "engineer"?

4) What things engineers do? (examples)

5) In what places engineers work?

6) How do you define "sustainability"?

7) Do you think that the understanding of "sustainability" is different in India and Tibet? **(yes / no / unsure)**

   How it is different? (if "yes")

8) How do you define "sustainable engineering"?

9) Do you think that the understanding of "sustainable engineering" is different in India and Tibet? **(yes / no / unsure)**
   How it is different? (if "yes")

10) The majority of your knowledge about engineering came from (choose one or more):
    - School library
    - Internet
    - School counselor
    - Magazines (which ones?) ________________________
    - Parents
    - Friends
    - Visit to parks or museums (which ones?)
      ____
    - Television (which programs?)
      ____
    - Movies (which ones?)
      ____
    - Science course(s) (which ones?)
      ____

11) Have you ever met an engineer? **(yes / no / unsure)**
    If yes:
    a) Is he or she a Tibetan?: _________________________
    b) *When* did you meet him/her?: ____
    c) *Where* did you meet him/her?:
       ____
    d) What was your impression about him or her?:
       ____
       _____
    e) What did you think about his or her work?
       ____
       _____

12) Do you personally know of a Tibetan who is studying engineering? **(yes / no / unsure)**
    - Where?:__________________________________

13) In what ways do you think that engineering has <u>improved</u> the life of people?

14) In what ways do you think that engineering has had <u>negative consequences</u>?

III. Tibetan identity

Answer the following questions as honest as possible. Remember that your questions are **confidential**.

15) What does it mean to be a Tibetan? (in your own view)

16) What makes a person a Tibetan? (characteristics) (in your own view)

17) How much **knowledge do you have of Tibetan Buddhism**? (in your own view) – *checkmark only one!*

Rate	***Checkmark***
Above the average Tibetan	
Average: As any other Tibetan	
Below the average Tibetan	
No knowledge in Tibetan Buddhism	
Unsure	

18) How much you **put into practice Tibetan Buddhism in your daily life**? (in your own view)—*checkmark only one!*

Rate	***Checkmark***
Above the average Tibetan	
Average: As any other Tibetan	
Below the average Tibetan	
No knowledge in Tibetan Buddhism	

Unsure	

19) *If applicable*: In which areas of your life Tibetan Buddhism has helped you more? You can give examples.

Appendix Q Post-course questionnaire

Now that you have taken the "Introduction to Engineering" short course, I will ask you similar questions I asked you in August. They might help you to reflect on your learning. They will help me in my research.

- **Your answers are confidential. If you do not understand a question, please ask me.**
- **Be honest answering these questions. Answer them without reading presentation slides**.
- ***Instructions*****:** Read each question. You may need to (1) circle the best option from the parenthesis, (2) checkmark form a list, OR (3) fill-in the blank when needed.

Name : ____

I. Influence of the course

1) *Now that you have taken the course and started your project*, checkmark **one** option that best describes your actual thoughts about studying engineering:

Statement	*Checkmark*
I am now *confident* that engineering is what I wish to study	
I am now *more interested* to study engineering	
I am now *considering* to study engineering	
No change at all: I was already confident that engineering *is* what I wish to study	
No change at all: I was already confident that engineering *is NOT* what I wish to study	
I am now *less interested* to study engineering	
I am now *confident* that engineering *is NOT* what I wish to study	
Other option:	

2) *If you are thinking of studying engineering*: what branch of engineering do you wish to study?:

____

______

Why?

____

3) *If you are NOT thinking of studying engineering*: what field of study is of your interest?:

____

______

Why?:

____

4) From a scale of 0 to 100 percent, how confident are you NOW that you will *become* an *engineer*?

____________**%**

5) Is this percentage **(** bigger / equal / smaller **)** than before taking the course?

II. <u>Understanding of engineering</u>

6) How do you define "engineering" *now*?

7) How do you define an "engineer" *now*?

8) **How do you define "sustainability" *now*?**

9) How do you define "sustainable engineering" ***now*****?**

10) In what ways do you think that engineering has *improved* the life of people?

11) In what ways do you think that engineering has had *negative consequences*?

12) If you were an engineer, how would you prevent negative consequences of engineering?

II. Future goals in science, technology, engineering, or mathematics:

13) If you have the opportunity to study engineering, **what are your dreams (goals)?** In other words**, what would you like to realize after an engineering (or other sciences) degree?**

III. Your comments about the course:

14) Did the **course** fit your expectations? **(** yes / no / partially / unsure **)**
Why?:____

____

____

Did the **way of presenting the course content** fit your expectations? **(** yes / no / partially / unsure **)**

Why?::____

15) Did the **course project** fit your expectations? **(** yes / no / partially / unsure **)**
Why?:

16) Did my **feedback sessions** fit your expectations to help you in your project? **(**yes / no / partially / unsure**)**
Why?:

17) What do you think of the way I connected engineering with Buddhism? (*example: when I mentioned dependent origination, the six perfections (virtues), interdependence, systems thinking and emptiness*)

18) What do you think of the way I connected engineering with examples relevant to your culture and surroundings? (*example: when I connected engineering with (1) the processes to make tingmos, (2) the processes to make dorjees in a metal-workshop in Mandwala, (3) paper recycling at the school, (4) the steps to make noodles in a factory in Clementtown, (4) photos of the school where structural components can be identified, (5) sustainability and photos of nomads and other Tibetans*)

19) Would you like to see *Tibetan engineers* teaching a course like this in *Tibetan* for senior students?
(yes / no / unsure)

Why?:____

20) What information would you **add** in the course content to be more helpful to Tibetan students?

21) What information would you **delete** in the course content to be more helpful to Tibetan students?

22) What information would you **correct** in the course content to be more helpful to Tibetan students?

23) Any other comments to me?

Appendix R Permission from an adult (18+) to document an artifact, structure, machine, technology, or technique

I, [*name of person or organization*], give authorization to Marisol Mercado Santiago to use the [*photographs, video, scanned document*] of [*artifact, structure, machine, technology, or technique*]. I understand that she will use the information in the "Introduction to Engineering" course that will be taught in 2012. I also understand that she will cite that the original artifact is of [*name of organization, name of person, family, or "unknown"*] and/or that the original media is of [*name of organization, name of person, family, or "unknown"*].

If the [*photographs, video, scanned document*] information is to be included in a publication, I understand that she will cite the owner's and artifact names stated above (otherwise, please, mark with a circle those names that you **do not** wish to be included in any publication).

For the purpose of her research, she can contact me at

E-mail address: __________________ [voluntary]

Postal address:

____ [voluntary]

Other way of communication: [e.g., Skype username, etc]

____________________________________ [voluntary]

Sincerely,

[Signature]

Date: [Month / Day / Year]

Location: [Voluntary]

(For researcher's use only) ID of the media: ____________________________

Appendix S Student 18 and older consent form

Research Project Number: ____________________

APPROVED
JUN 04 2012
EXPIRES 6/3/2013
PURDUE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

STUDENT 18 AND OLDER CONSENT FORM
"A Case Study of Tibetan Students Learning an Introduction to Engineering"

Dr. Alice L. Pawley
Purdue University
School of Engineering Education

Purpose of Research

The purposes of the research are two:

(1) To understand how Tibetan culture and Buddhism influence in the engineering thinking of Tibetans in exile
(2) To understand the actions that Marisol did with the Tibetan community in exile to develop and teach an introduction to engineering that is culturally appropriate for Tibetans students

Dr. Alice L. Pawley and doctoral candidate Marisol Mercado Santiago will use this this knowledge in the following ways:

(1) Correct the course and ways of teaching to Tibetan course
(2) Help Tibetans' efforts to have a culturally sensitive engineering education
    - The course will be free for the students
    - The course content will be shared with those Tibetans who are interested
(3) Demonstrate how Tibetan culture and Buddhism are important in the engineering thinking and learning of Tibetan students in exile
(4) Help other engineering educators who wish to develop culturally sensitive engineering education for specific indigenous groups

Specific Procedures

You will get (1) copy of the consent form (this document), (2) copy of the course topics, (3) project description, and (4) information of where and when the class will meet. Please read those documents carefully. Marisol will answer your concerns. If you decide to participate in the study, you need to sign this document.

You need to: (1) attend classes (at least 75% of the classes, for example, 11 out of 14 classes), (2) come to a group interview before the cuorse starts, (3) do the course project and progress reports, and (4) have your own pencil, notebook, papers, and a big envelope. If you have any concerns, contact Marisol via e-mail (msantiago16@purdue.edu) or via phone number: [TO BE DEFINED].

Marisol will keep a copy of your course project and progress reports. In class, Marisol will take fieldnotes (observations) of you. Those observations and copy of the project will help Marisol to answer her first research question*: how Tibetan culture and Buddhism influence in the engineering thinking of the students?*

If you have special needs, please notify Marisol to make arrangements for them.

Duration of Participation

- 2 classes per week (or as adviser by the school director). 1 hour per class.
- The group interview may be between 1 hour to 1 ½ hour.
- The final class may be between 1 and 2 hours (depending on the size of the class).

Research Project Number: ____________________

Risks
There are some risks associated to participating in this research. The final course project may represent a risk for you if you do not choose appropriately a Tibetan community member(s) to interview. As part of the course project, you will interview one or more community members who is experiencing a problem in the community (related to infrastructure and/or technology) and document the problem following a questions guide. You should choose only those familiar members of the community whom you trust. If a problem happens, you can ask Marisol to change the community member. Nothing bad will happen to you if you decide to change a community member.

You will be participating in a class that may help you understand what is engineering, as understood in Western-academic contexts. Please feel free to interrupt Marisol in class if the topic is not making you feel comfortable.

Break of confidentiality is a risk of participating in this study. Marisol will take photos and videos in some of the classes and students' activities in class. Your face will be blurred in the images and videos to prevent someone to identify you. You will be assigned a number in the records. Your personal information (including your name) will be replaced by pseudonyms (generic names that do not identify you).

Benefits
There are no benefits for participating in this research and attending class.

There are some *indirect* benefits:

- You may learn new things about engineering by participating in the course and doing the project.
- After Marisol teaches the class, the copy of the course content will be free for those Tibetans who wish it. Checkmark item (1) after your signature in the last page to receive copy of the course.
- You will have a certificate of completion upon completing the course. To successfully complete the course you need:
    - To participate in the group interview
    - To answer the pre- and post- test
    - To attended 75% or more of the class lessons (for example, 11 out of 14 classes)
    - To submit the final course project and present it in class
- We cannot guarantee enrollment in a university or scholarship after this course, but Marisol can write a recommendation letter for you if you successfully complete the course and need it for university. You may request it via e-mail or mailing address (see Contact Information section).

Compensation
There is no compensation for participating in the study and attending class.

Extra Costs to Participate
Classroom items: A notebook, pencil and/or pen, some papers, and a big envelope. If you cannot bring these items you are still welcome to participate; they will just improve your experience and learning.

Confidentiality
In addition to Marisol, the research records may be read by Dr. Alice L. Pawley, the principal investigator who is supervising this research that is Marisol's doctoral project. Also, the project's research records may be reviewed by the National Science Foundation and by departments at Purdue University responsible to regulate research.

Research Project Number: ____________

Audio of the group interview and videos (if any) will be transcribed by Marisol Mercado Santiago or a professional transcription agency.

Storage of your records:
Your *paper records* will be assigned a number to protect your privacy. They will be stored in a locked cabinet at Purdue University. The *digital (electronic) records* will be stored in a password-protected computer system. The digital records will be *encrypted*, meaning that a computer technique will only give access to Marisol and Alice. *Examples of digital records* are photos, videos, audio, scanned consent forms, transcripts, copy of your course project and project progress reports, and observations of your participation in the study.
Both, the paper and electronic records, will be accessed only by Marisol Mercado Santiago and Dr. Alice L. Pawley.

When your data will be destroyed:
Your record will be stored up to five years after Marisol's graduation (expected to be on December 2013). After the fifth year, we will securely discard the papers of your record at Purdue University and we will erase your digital records stored in the computer system. Your data may be used in a future for the following:

(1) To contact you in case that you would like to participate in another research
(2) To contact you in case that Marisol knows of education opportunities that might interest you

To permit Marisol to contact you in a future, checkmark item (3) after your signature in the last page.

How your data will be used in the results:
After we remove your personal information, it will be analyzed to help us answer the research questions. The results of this project will be shared in conferences, books, journal publications, and presentations related to Buddhist studies, education, and Tibetan studies. In addition, if you wish copy of future results, you are free to contact Marisol (see "Contact Information" section).

Voluntary Nature of Participation
Your participation is voluntary. You do not have to participate in this research project. You can stop your participation at any time. Nothing bad will happen to you if you stop your participation.

Remember that a break of confidentiality is a risk of participating in this study. If you think that you or your family in Tibet may be at risk if you are identified by Chinese authorities, consider stopping your participation in this study. Notify the researcher immediately (see next section).

Contact Information:
If you have any questions about this research project, you can contact:

Dr. Alice L. Pawley apawley@purdue.edu 1-765-496-1209 Purdue University Armstrong Hall Room 1325 701 W. Stadium Ave. West Lafayette, IN, 47907-2045 USA	Marisol Mercado Santiago msantiago16@purdue.edu 1-765-494-0375 Purdue University, Potter 248 500 Central Dr. West Lafayette, IN, 47907-2022 USA

Participant's initials:__________ Date: __________

Research Project Number: ____________________

If you have concerns about the treatment of research participants, you can contact the *Institutional Review Board at Purdue University*, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114.

The phone number for the Board is 1-765-494-5942. The email address is irb@purdue.edu.

Documentation of Informed Consent

I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research project and my questions have been answered. I am prepared to participate in the research project described above. I will receive a copy of this consent form after I sign it.

______________________ ______________

Participant's Signature Date

____

Participant's Name

______________________ ______________

Researcher's Signature Date

(1) Are you interested to have a free copy of the course (curricula)?: ☐
E-mail address to send the course materials: ____________________

(2) I understand that my face will be blurred in all photos and videos to prevent my personal identification: ☐

(3) May Marisol contact you in a future if she knows of education, scholarship, and/or research opportunities that may interest you? : ☐

Appendix T Assent form for students 16 or 17 years old

Research Project Number: ______________________

Assent Form for Students 16 or 17 Years Old

APPROVED
JUN 04 2012
EXPIRES 6/3/2013
PURDUE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Project Title: A Case Study of Tibetan Students Learning an Introduction to Engineering
Investigator: Dr. Alice L. Pawley
Doctoral candidate: Marisol Mercado Santiago

Introduction:
Tashi delek! We are doing a research study. A research study is a special way to find out about things. We want to understand the following:

(1) How Tibetan culture and Buddhism influence in the engineering thinking of Tibetan students in exile?
(2) The activities ("steps") that Marisol did with the Tibetan community in exile to develop and teach an Introduction to Engineering course that can be culturally appropriate for Tibetans

What do you need to do:
You can be in this study if you wish. As part of the study, you will need to go to a class titled "Introduction to Engineering." In addition, you need to do the following:

- Attend *at least* 75% of the classes (for example, 11 out of 14)
- Come to a group interview *before* the course starts
- Do the course project and progress reports
- Have some school materials such as a pencil, notebook, some papers, and a big envelope. (If you cannot get these things, there is no problem. You can still participate).

The class is expected to meet 2 times per week. 1 hour per class. The group interview might be between 1 and 1½ hours. The final class might be between 1 and 2 hours. This might change.

What Marisol will do:
Marisol will be the teacher and the researcher. In class, Marisol will also be writing fieldnotes (observations) of you. Marisol, will keep a copy of your course project and progress reports. Those observations and copy of your project will help Marisol to answer her first research question*: how Tibetan culture and Buddhism influence in the engineering thinking of the students?*

If you have special needs, please tell Marisol. She will help you make arrangements.

What unfortunate things might happen to you (risks):
Your name will not be used in the study. We will assign you a number and a different name in the study. In any photos or videos, we will blur your face to protect your privacy. "Blur" means that your face will look "foggy" in the images. These are steps that we will take to protect your privacy. Even though of these ways to protect you, there is a risk that someone might identify that you participated in the research.

The second risk is that uncomfortable experiences might happen if you do not choose a good Tibetan community member to interview As part of the course project, you will interview one or more community members who is experiencing a problem in the community (related to infrastructure and/or technology) and document the problem following a questions guide. You should choose only those familiar person(s) whom you trust. If a problem happens, you can ask Marisol to change the community member. Nothing bad will happen to you if you decide to change.

Research Project Number: ______________________

The third risk is that you might feel uncomfortable when the class is discussing topics about engineering. Feel free to interrupt Marisol in class if the topic is making you feel uncomfortable.

What are the benefits (good things):
There are *no direct benefits* for participating in this research and attending class.

There are some *indirect* benefits:
- You may learn new things about engineering
- You will have a certificate of completion after you complete the course. To successfully complete the course you need:
    - To participate in the group interview
    - To answer the pre- and post- test
    - To attended 75% or more of the class lessons (for example, 11 out of 14 classes)
    - To submit the final course project and present it in class

We cannot guarantee enrollment in a university or scholarship after this course, but Marisol can write a recommendation letter for you if you successfully complete the course. You may request it via e-mail (msantiago16@purdue.edu) or personally to Marisol.

Protecting your privacy:
In addition to Marisol, your record in the project may be read by Dr. Alice L. Pawley, the National Science Foundation, and by departments at Purdue University responsible to regulate researches.

You will have a number and a different name in the study. Your *digital (electronic) record* will be *encrypted* in our research records, meaning that only Alice and Marisol will be able to see it. Your *paper record* will be stored in a secure file cabinet at Purdue University. *All of your records will be stored up to five years after Marisol's graduation (expected to be on December 2013).* After the fifth year, we will discard your records.

Your data may be used in a future for the following purposes: to contact you in case that you would be interested to participate in another research *or* in case that we know of education/scholarship opportunities for you. If you wish these future communications, please checkmark at the end of this form.

Results of the study:
When we are done with the study, we will write reports about what we found out. We will not use information that can identify you in the reports.

Voluntary nature of the study:
You don't have to be in this study. Nothing bad will happen if you decide to stop your participation. No one will punish you if you want to stop your participation later.

If you want to be in this study, please sign your name:

I, ______________________________, want to be in this research study.
(write your name here)

______________________________ ______________
Investigator signature (Date)

Marisol can contact me in a future to let me know of education, scholarship, and/or research opportunities: ☐

Appendix U Parental or legal guardian consent form

Research Project Number:

APPROVED
JUN 04 2012
EXPIRES 6/3/2013
PURDUE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

PARENTAL OR LEGAL GUARDIAN CONSENT FORM
"A Case Study of Tibetan Students Learning an Introduction to Engineering"
Dr. Alice L. Pawley
Purdue University
School of Engineering Education

Purpose of Research
The purposes of the research are two:

(1) To understand how Tibetan culture and Buddhism influence in the engineering thinking of Tibetans in exile
(2) To understand the actions that Marisol did with the Tibetan community in exile to develop and teach an introduction to engineering that is culturally appropriate for Tibetans students

Dr. Alice L. Pawley and doctoral candidate Marisol Mercado Santiago will use this this knowledge in the following ways:

(1) Correct the course and ways of teaching to Tibetan students
(2) Help Tibetans' efforts to have an engineering education that is culturally sensitive
  - The course and content will be free for Tibetans
  - The course content will be shared with those Tibetans who are interested
(3) Demonstrate how Tibetan culture and Buddhism are important in the engineering thinking and learning of Tibetan students in exile
(4) Help other engineering educators who wish to develop an engineering education that is culturally sensitive for ethnic groups

Specific Procedures
You will get (1) copy of the consent form (this document), (2) copy of the course topics, (3) project description, and (4) information of where and when the class will meet. Please read those documents carefully. Marisol will answer your concerns. If you decide to give permission to your child to participate in the study and class, you need to sign this consent form.

Marisol will keep a copy of your child's course project and progress reports. In the classes, Marisol will take notes (observations) of your child. Marisol will keep a copy of your child's final project and progress reports. These documents and observations will help Marisol to answer her first research question.

You as a parent need to: (1) make sure that your child is attending classes (at least 75% of the classes, for example, 11 out of 14 classes), (2) bring your child to the group interview, (3) check that your child is doing the course project, and (4) supply pencils, a notebook, papers, and a big envelope. Any other concerns, you are welcome to contact Marisol personally, via e-mail (msantiago16@purdue.edu), or via phone number: [TO BE DEFINED IN INDIA].

If your child has special needs, please notify Marisol to make arrangements for them.

Duration of Participation

- 2 classes per week (or as advised by the school director). 1 hour per class.
- The group interview may be between 1 hour to 1 ½ hour
- The final class may be between 1 and 2 hours (depending on the size of the class)

Research Project Number: ______________________

Risks

There are risks associated to participating in this research. The course project may represent a risk if your child does not choose a correct Tibetan community member(s) to interview. As part of the course project, your child will interview one community member who is experiencing a problem in the community (related to infrastructure and/or technology) and document the problem following a questions guide. Your child should only choose a familiar community member. If a problem happens, your child or you can ask Marisol to change the community member. Nothing bad will happen to your child if he or she chooses to change a community member.

Your child will be participating in a class that may help him or her understand what is engineering, as understood in Western-academic contexts. Your child is free to interrupt Marisol in class if the topic is making him or her uncomfortable.

Break of confidentiality is a risk of participating in this study. Marisol will take photos and videos in some of the classes and students' activities in class. Your child's face will be blurred in all photos and videos to prevent identification. Your child will be assigned a number in the project's records. Your child's and family's personal information will be replaced by pseudonyms (different names that cannot identify your child).

Benefits

There are no benefits for your child for participating in this research and attending class.

There are some *indirect* benefits:

- Your child may learn new things about engineering by participating in the course and doing the project.
- After Marisol teaches the class, the copy of the course content will be free for those Tibetans who wish it. Checkmark item (1) after your signature in the last page to receive copy of the course.
- Your child will have a certificate of completion upon completing the course. To successfully complete the course s/he needs:
    - To participated in the group interview
    - To answered the pre- and post- test
    - To attended 75% or more of the classes (for example, 11 out of 14 classes)
    - To submit the course project and present it in class
- We cannot guarantee enrollment in a university or scholarship after this course, but Marisol can write a recommendation letter for your child if he or she successfully completes the course and need it for university. You or your child may request it via e-mail or mailing address (see Contact Information section).

Compensation

There is no compensation for participating in the study and attending class.

Extra Costs to Participate

Classroom items: A notebook, pencil and/or pen, some papers, and a big envelope. If you cannot bring these items you are still welcome to participate; they will just improve your experience and learning.

Confidentiality

In addition to Marisol, the research records may be read by Dr. Alice L. Pawley, the principal investigator who is supervising this research that is Marisol's doctoral project. Also, the project's research records may be reviewed by the National Science Foundation and by departments at Purdue University responsible to regulate research.

Audio of the group interview and videos (if any) will be transcribed by Marisol Mercado Santiago or a professional transcription agency.

Research Project Number: ___________________________

Storage of your child's records:
Your child's *paper records* will be assigned a number to protect his or her privacy. They will be stored in a locked cabinet at Purdue University. The *digital (electronic) records* will be stored in a password-protected computer system. The digital records will be *encrypted*, meaning that a computer technique will only give access to Marisol and Alice. *Examples of digital records* are photos, videos, audio, scanned consent forms, transcripts, copy of your child's course project and project progress reports, and observations of your child's participation in the study. Both, the paper and electronic records, will be accessed only by Marisol Mercado Santiago and Dr. Alice L. Pawley.

When your child's data will be destroyed:
Your record will be stored up to five years after Marisol's graduation (expected to be on December 2013). After the fifth year, we will securely discard the papers of your record at Purdue University and we will erase your digital records stored in the computer system. Your data may be used in a future for the following:

(1) To contact you in case that you —or your child if s/he is an adult already— would like to participate in another research
(2) To contact you in case that Marisol knows of education opportunities that might interest you or your child

<u>To permit Marisol to contact you in a future, checkmark item (3) after your signature in the last page.</u>

How your child's data will be used in the results:
After we remove your child's personal information, it will be analyzed to help us answer the research questions. The results of this project will be shared in conferences, books, journal publications, and presentations related to Buddhist studies, education, and Tibetan studies. In addition, if you wish copy of future results, you are free to contact Marisol (see "Contact Information" section).

<u>Voluntary Nature of Participation</u>
Your child's participation is voluntary. Your child does not have to participate in this research project. You can stop your child's participation at any time. Nothing bad will happen if you stop your child's participation.

Remember that a break of confidentiality is a risk of participating in this study. If you think that you, your child, or your family in Tibet may be at risk if you are identified by Chinese authorities, consider stopping your participation in this study. Notify the researcher immediately (see next section).

<u>Contact Information</u>
If you have any questions about this research project, you can contact:

<u>Dr. Alice L. Pawleyapawley@purdue.edu</u> 1-765-496-1209 Purdue University Armstrong Hall Room 1325 701 W. Stadium Ave. West Lafayette, IN, 47907-2045 USA	<u>Marisol Mercado Santiago</u> <u>msantiago16@purdue.edu</u> 1-765-494-0375 Purdue University, Potter 248 500 Central Dr. West Lafayette, IN, 47907-2022 USA

If you have concerns about the treatment of research participants, you can contact the *Institutional Review Board at Purdue University*, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114.

Research Project Number: ________________________________

The phone number for the Board is 1-765-494-5942. The email address is irb@purdue.edu.

Documentation of Informed Consent

I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research project and my questions have been answered. I am prepared to permit my child, whose name is ____, to participate in the research project described above. I will receive a copy of this consent form after I sign it.

____ ________________________

Parent's Signature Date

____

Parent's Name

____ ________________________

Researcher's Signature Date

(1) Are you interested to have a free copy of the course (curricula): ☐

E-mail address to send the course materials: ____________________________

(2) I understand that my child's face will be blurred in all photos and videos to prevent my child's personal identification: ☐

(3) May Marisol contact you in a future if she knows of education, scholarship, and/or research opportunities that may interest you? : ☐

Appendix V Teacher, school administrator, cultural, or technical expert consent form

Research Project Number: ____________________

APPROVED
JUN 04 2012
EXPIRES 6/3/2013
PURDUE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

TEACHER, SCHOOL ADMINISTRATOR,
CULTURAL OR TECHNICAL EXPERT CONSENT FORM

"A Case Study of Tibetan Students Learning an Introduction to Engineering"

Dr. Alice L. Pawley
Purdue University
School of Engineering Education

Purpose of Research

The purposes of the research are two:

(1) To understand how Tibetan culture and Buddhism influence in the engineering thinking of Tibetans in exile
(2) To understand the actions that Marisol did with the Tibetan community in exile to develop and teach an introduction to engineering that is culturally appropriate for Tibetans students

Dr. Alice L. Pawley and doctoral candidate Marisol Mercado Santiago will use this this knowledge in the following ways:

(1) Correct the course and ways of teaching to Tibetan students
(2) Help Tibetans' efforts to have an engineering education that is culturally sensitive
   - The course and content will be shared for free for Tibetans
(3) Demonstrate how Tibetan culture and Buddhism are important in the engineering thinking and learning of Tibetan students in exile
(4) Help other engineering educators who wish to develop an engineering education that is culturally sensitive for ethnic groups

Specific Procedures

You will receive copy of this document and details of the course. Before the interview, you will have 20 minutes (or more as needed) to read the course and project details. Voluntary, you will be interviewed.

First, Marisol will ask your personal information. Then Marisol will ask you questions about the cultural content of the course, technical content of the course, and/or ways of teaching for high school (pre-university) Tibetan students, and so on. Marisol will ask you about your recommendations on the course topics and project. This will help us to correct the content and ways of teaching the course to Tibetans. If you do not feel comfortable to answer a question, you can tell Marisol "pass question" (or as you prefer) to pass to the next one.

Your personal interview (or interview in a group) will be audio-recorded and transcribed. Pseudonyms (different names) will be placed in the transcript to remove information that may identify you, such as your name, school where you graduated, and so on.

Duration of Participation

We anticipate that the personal interview (or interview in a group) may take 80 minutes (20 minutes of reviewing the course content and 60 minutes of interviewing in total).

Risks

There are some risks associated to participating in this research. Depending on your life circumstances, you may start remembering past experiences that may be sensitive. These experiences may give you distress.

Research Project Number: ____________________________

Feel free to pass a question (or stop answering it) if it makes you feel uncomfortable or you think that giving the information will put your life at risk.

Break of confidentiality is a risk of participating in this study. To help protect you, we will use pseudonyms and we will put different codes on those areas of the transcript that may identify you. You may also say that you do not wish to give us permission to use your photo in publications. Checkmark item (2) after your signature in the last page of this consent form to indicate that you do give us permission to use your photo in publications.

Benefits

There are no direct benefits for participating in this research. The indirect benefit is that the copy of the course content will be shared (for free) for those Tibetans who express interest. If you are interested, please checkmark item (1) below your signature in the last page.

Compensation

A compensation of $10 will be given to you for your participation.

Confidentiality

In addition to Marisol, the research records may be read by Dr. Alice L. Pawley, the principal investigator who is supervising this research that is Marisol's doctoral project. Also, the project's research records may be reviewed by the National Science Foundation and by departments at Purdue University responsible to regulate research. Audio of the interview and videos (if any) will be transcribed by Marisol Mercado Santiago or a professional transcription agency.

Storage of your records:

Your *paper records* will be assigned a number to protect your privacy. They will be stored in a locked cabinet at Purdue University. The *digital (electronic) records* will be stored in a password-protected computer system. The digital records will be *encrypted*, meaning that a computer technique will only give access to Marisol and Alice. *Examples of digital records* are photos, videos, audio, scanned consent forms, transcripts, and observations of your participation in the study.

Both, the paper and electronic records, will be accessed only by Marisol Mercado Santiago and Dr. Alice L. Pawley.

When your data will be destroyed:

Your record will be stored up to five years after Marisol's graduation (expected to be on December 2013). After the fifth year, we will securely discard the papers of your record at Purdue University and we will erase your digital records stored in the computer system. Your data may be used in a future for the following:

(1) To contact you in case that you would like to participate in another research
(2) To contact you in case that Marisol knows of education opportunities that might interest you or your students

To permit Marisol to contact you in a future, checkmark item (3) after your signature in the last page.

How your data will be used in the results:

After we remove your personal information, it will be analyzed to help us answer the research questions. The results of this project will be shared in conferences, books, journal publications, and presentations related to Buddhist studies, education, and Tibetan studies. In addition, if you wish copy of future results, you are free to contact Marisol (see "Contact Information" section).

Research Project Number: ______________________________

Voluntary Nature of Participation

Your participation is voluntary. You do not have to participate in this research project. You can stop your participation at any time. Nothing bad will happen to you if you stop your participation.

Remember that a break of confidentiality is a risk of participating in this study. If you think that you or your family in Tibet may be at risk if you are identified by Chinese authorities, consider stopping your participation in this study. Notify the researcher immediately (see next section).

Contact Information:

If you have any questions about this research project, you can contact:

Dr. Alice L. Pawley	Marisol Mercado Santiago
apawley@purdue.edu	msantiago16@purdue.edu
1-765-496-1209	1-765-494-0375
Purdue University Armstrong Hall Room 1325 701 W. Stadium Ave. West Lafayette, IN, 47907-2045 USA	Purdue University, Potter 248 500 Central Dr. West Lafayette, IN, 47907-2022 USA

If you have concerns about the treatment of research participants, you can contact the *Institutional Review Board at Purdue University*, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114. The phone number for the Board is 1-765-494-5942. The email address is irb@purdue.edu.

Documentation of Informed Consent

I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research project and my questions have been answered. I am prepared to participate in the research project described above. I will receive a copy of this consent form after I sign it.

______________________________ ______________________
Participant's Signature Date

____
Participant's Name

______________________________ ______________________
Researcher's Signature Date

(1) Are you interested to have a free copy of the course (curricula)?: ☐
E-mail address to send the course materials: ______________________

(2) May I use your photos and/or videos in publications or presentations?: ☐

(3) May Marisol contact you in a future if she knows of education, scholarship, and/or research opportunities that may interest you? : ☐

Appendix W Non-Tibetan community member consent form

Research Project Number: ______________________________

APPROVED
JUN 04 2012
EXPIRES 6/3/2013
PURDUE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

NON-TIBETAN COMMUNITY MEMBER CONSENT FORM
"A Case Study of Tibetan Students Learning an Introduction to Engineering"
Dr. Alice L. Pawley
Purdue University
School of Engineering Education

Purpose of Research
The purposes of the research are two:

(1) To understand how Tibetan culture and Buddhism influence in the engineering thinking of Tibetans in exile
(2) To understand the actions that Marisol did with the Tibetan community in exile to develop and teach an introduction to engineering that is culturally appropriate for Tibetans students

Dr. Alice L. Pawley and doctoral candidate Marisol Mercado Santiago will use this this knowledge in the following ways:

(1) Correct the course and ways of teaching to Tibetan students
(2) Help Tibetans' efforts to have an engineering education that is culturally sensitive
  - The course and content will be free for Tibetans
(3) Demonstrate how Tibetan culture and Buddhism are important in the engineering thinking and learning of Tibetan students in exile
(4) Help other engineering educators who wish to develop an engineering education that is culturally sensitive for ethnic groups

Specific Procedures
You will receive copy of the consent form and details of the course. Before the interview, you will have 20 minutes (or more as needed) to read the course details. Voluntary, you will be interviewed. First, Marisol will ask you demographics questions. Then Marisol will ask you about any of the following (if applicable to your experience): Tibetan schools in the community, English level of Tibetan students, resources of the Tibetan schools, and so on. You will be invited to give your recommendations about the course and project. This will help Marisol to correct the content and ways of teaching the course to Tibetans. If you do not feel comfortable to answer a question, you can tell Marisol "pass question" (or as you prefer) to pass to the next one.

Your personal interview will be audio-recorded and transcribed. Pseudonyms (generic names) will be placed along the transcripts to remove information that may identify you, such as your name, school where you graduated, and so on.

Duration of Participation
We anticipate that the personal interview may take 60 minutes or less (20 minutes of reviewing the course content and 40 minutes of interviewing in total).

Risks
There are some risks associated to participating in this research. Depending on your life circumstances, you may remember experiences that may be sensitive or cause you distress. Feel free to skip a question (or stop answering it) if it makes you feel uncomfortable.

Break of confidentiality is a risk of participating in this study. To help you not identify you, we will use pseudonyms and your record will have a number instead of your name. You may also say that you do not wish to

Research Project Number: ______________________________

give us permission to use your photo in publications. Checkmark item (1) after your signature in the last page of this consent form to give us permission to use your photo in publication.

Benefits

There are no direct benefits for participating in this research.

Compensation

A compensation of $10 will be given to you for your participation.

Confidentiality

In addition to Marisol, the research records may be read by Dr. Alice L. Pawley, the principal investigator who is supervising this research that is Marisol's doctoral project. Also, the project's research records may be reviewed by the National Science Foundation and by departments at Purdue University responsible to regulate research. Audio of the interview and videos (if any) will be transcribed by Marisol Mercado Santiago or a professional transcription agency.

Storage of your records:

Your *paper records* will be assigned a number to protect your privacy. They will be stored in a locked cabinet at Purdue University. The *digital (electronic) records* will be stored in a password-protected computer system. The digital records will be *encrypted*, meaning that a computer technique will only give access to Marisol and Alice. *Examples of digital records* are photos, videos, audio, scanned consent forms, transcripts, and observations of your participation in the study.

Both, the paper and electronic records, will be accessed only by Marisol Mercado Santiago and Dr. Alice L. Pawley.

When your data will be destroyed:

Your record will be stored up to five years after Marisol's graduation (expected to be on December 2013). After the fifth year, we will securely discard the papers of your record at Purdue University and we will erase your digital records stored in the computer system. Your data may be used in a future for the following:

(1) To contact you in case that you would like to participate in another research

To permit Marisol to contact you in a future, checkmark item (3) after your signature in the last page.

How your data will be used in the results:

After we remove your personal information, it will be analyzed to help us answer the research questions. The results of this project will be shared in conferences, books, journal publications, and presentations related to Buddhist studies, education, and Tibetan studies. In addition, if you wish copy of future results, you are free to contact Marisol (see "Contact Information" section).

Voluntary Nature of Participation

Your participation is voluntary. You do not have to participate in this research project. You can stop your participation at any time, with no negative consequences.

Research Project Number: ______________________

Contact Information:

If you have any questions about this research project, you can contact:

Dr. Alice L. Pawley	Marisol Mercado Santiago
apawley@purdue.edu	msantiago16@purdue.edu
1-765-496-1209	1-765-494-0375
Purdue University	Purdue University, Potter 248
Armstrong Hall Room 1325	500 Central Dr.
701 W. Stadium Ave.	West Lafayette, IN, 47907-2022
West Lafayette, IN, 47907-2045	USA
USA	

If you have concerns about the treatment of research participants, you can contact the *Institutional Review Board at Purdue University*, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114. The phone number for the Board is 1-765-494-5942. The email address is irb@purdue.edu.

Documentation of Informed Consent

I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research project and my questions have been answered. I am prepared to participate in the research project described above. I will receive a copy of this consent form after I sign it.

______________________ ______________________

Participant's Signature Date

____

Participant's Name

______________________ ______________________

Researcher's Signature Date

(1) May I use your photos and/or videos in publications or presentations?: ☐

(2) May Marisol contact you in a future if she knows of research opportunities that may interest you? : ☐

Appendix X Teacher assistant consent form

Research Project Number: ___________________________

APPROVED
JUN 04 2012
EXPIRES 6/3/2013
PURDUE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

TEACHER ASSISTANT-TRANSLATOR CONSENT FORM
"A Case Study of Tibetan Students Learning an Introduction to Engineering"
Dr. Alice L. Pawley
Purdue University
School of Engineering Education

Purpose of Research
The purposes of the research are two:

(1) To understand how Tibetan culture and Buddhism influence in the engineering thinking of Tibetans in exile
(2) To understand the actions that Marisol did with the Tibetan community in exile to develop and teach an introduction to engineering that is culturally appropriate for Tibetans students

Dr. Alice L. Pawley and doctoral candidate Marisol Mercado Santiago will use this this knowledge in the following ways:

(1) Correct the course and ways of teaching to Tibetan students
(2) Help Tibetans' efforts to have an engineering education that is culturally sensitive
    - The course and content will be free for Tibetans
(3) Demonstrate how Tibetan culture and Buddhism are important in the engineering thinking and learning of Tibetan students in exile
(4) Help other engineering educators who wish to develop an engineering education that is culturally sensitive for ethnic groups

Specific Procedures
You will receive copy of the consent form and details of the course. You will attend every class starting from the students' group interview and up to the last class (project presentation). You may decide not to attend a class if you are feeling sick or if an unfortunate event happened in your life. If possible, call or e-mail in advance to tell Marisol that you will not be in the class. You will not receive compensation for those days that you did not go to the class.

You will help students in translating from English to Tibetan and Tibetan to English in those moments that a student need support translation (if any). In addition, you may give materials to students, take photos and videos, and help Marisol translate some words in Tibetan.

During the class, group interview, and final presentation of the students, Marisol may take photos and videos. You will have a different name and code in the research study. Any personal information that may identify you will be replaced with a pseudonym.

Marisol may take notes (observations in class) that may include you, but she will use a different name to refer to you.

Duration of Participation

- 2 classes per week (or as adviser by the school director). 1 hour per class.
- The focus group may be between 1 hour to 1 ½ hour.
- The final class may be between 1 and 2 hours (depending on the size of the class).

Risks
There are some risks associated to participating in this research. You will be working with students who may need help in translation. Depending on your experience as a translator and/or teacher, some interactions with the students may cause you stress. Feel free to discuss alternative ways of interaction or other potential accommodations before

or during the class with Marisol (see Contact Information section).

Marisol will take photos and videos of students' activities in class. Break of confidentiality is a risk of participating in this study. People may identify you and might put your life at risk (if applicable). If you prefer, Marisol can blur your face in photos and videos. Check mark option number 2 after the signature section to let Marisol know that you wish your face to be blurred in photos and videos.

Benefits

There are no direct benefits for participating in this research.
There are some indirect benefits. You may learn new things about engineering. You will receive a certificate of completion after your participation in the course. If you need a recommendation letter in a future, contact Marisol (see section Contact Information). The copy of the course content will be shared for free for those Tibetans who express interest. Checkmark item (1) after your signature in the last page of this consent form to receive copy of the content.

Compensation

$10 per class attended. No more than $20 per week, no more than $160 per entire course. No compensation if you do not attend the class.

Confidentiality

In addition to Marisol, the research records may be read by Dr. Alice L. Pawley, the principal investigator who is supervising this research that is Marisol's doctoral project. Also, the project's research records may be reviewed by the National Science Foundation and by departments at Purdue University responsible to regulate research. Audio of the interview and videos (if any) will be transcribed by Marisol Mercado Santiago or a professional transcription agency.

Storage of your records:

Your *paper records* will be assigned a number to protect your privacy. They will be stored in a locked cabinet at Purdue University. The *digital (electronic) records* will be stored in a password-protected computer system. The digital records will be *encrypted*, meaning that a computer technique will only give access to Marisol and Alice. *Examples of digital records* are photos, videos, audio, scanned consent forms, transcripts, and observations of your participation in the study.
Both, the paper and electronic records, will be accessed only by Marisol Mercado Santiago and Dr. Alice L. Pawley.

When your data will be destroyed:

Your record will be stored up to five years after Marisol's graduation (expected to be on December 2013). After the fifth year, we will securely discard the papers of your record at Purdue University and we will erase your digital records stored in the computer system. Your data may be used in a future for the following:

(1) To contact you in case that you would like to participate in another research
(2) To contact you in case that Marisol knows of education opportunities that might interest you or your students

To permit Marisol to contact you in a future, checkmark item (3) after your signature in the last page.

How your data will be used in the results:

After we remove your personal information, it will be analyzed to help us answer the research questions. The results of this project will be shared in conferences, books, journal publications, and presentations related to Buddhist studies, education, and Tibetan studies. In addition, if you wish copy of future results, you are free to contact Marisol (see "Contact Information" section).

Research Project Number: ______________________________

Voluntary Nature of Participation

Your participation is voluntary. You do not have to participate in this research project. You can stop your participation at any time. Nothing bad will happen to you if you stop your participation.

Remember that a break of confidentiality is a risk of participating in this study. If you think that you or your family in Tibet may be at risk if you are identified by Chinese authorities, consider to stop your participation in this study. Notify the researcher immediately (see next section).

Contact Information:

If you have any questions about this research project, you can contact:

Dr. Alice L. Pawley apawley@purdue.edu 1-765-496-1209 Purdue University Armstrong Hall Room 1325 701 W. Stadium Ave. West Lafayette, IN, 47907-2045 USA	Marisol Mercado Santiago msantiago16@purdue.edu 1-765-494-0375 Purdue University, Potter 248 500 Central Dr. West Lafayette, IN, 47907-2022 USA

If you have concerns about the treatment of research participants, you can contact the *Institutional Review Board at Purdue University*, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114. The phone number for the Board is 1-765-494-5942. The email address is irb@purdue.edu.

Documentation of Informed Consent

I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research project and my questions have been answered. I am prepared to participate in the research project described above. I will receive a copy of this consent form after I sign it.

______________________________ ______________________________

Participant's Signature Date

____

Participant's Name

______________________________ ______________________________

Researcher's Signature Date

(1) Are you interested to have a free copy of the course (curricula)?: ☐

E-mail address to send the course materials: ______________________________

(2) Do you prefer your face to be blurred in photos and/or videos? ☐

(3) May Marisol contact you in a future if she knows of education, scholarship, and/or research opportunities that may interest you? : ☐

Appendix Y List of reflective questions asked in each of the electronic presentations

Lesson	Reflective questions
1.1	What is innovation? What is an invention? What is design? What are “constraints”? Why do engineers design under “constraints”?
1.2	If an engineer is going to design a machine to make *tingmos* [steamed bread], how important is to understand the steps to make them? Can a *tingmo*-production machine designed by an engineer be beneficial in all contexts? If we put the machine in home #6, could it limit (or facilitate) the transfer of knowledge on how to make *tingmos* to the next generations? -- Questions in the supplementary documents of this lesson (refer to Appendix N): What other questions comes to your mind when you read the project information? What other information you should know to design a better solution? What would you have done differently?
2.1	In what ways the processes to make *dorjees* [a Tibetan Buddhism ritual instrument] are similar or different to engineering? In what ways engineering is related to a Tibetan noodles factory in Clementown?
2.2	No reflective questions, although I wrote the questions: “What do you know about the steps to design a *chorten*? (A *chorten* is a structure constructed to symbolize the mind of the Buddha) Can you see concepts of structural engineering in this photo?
3.1	What are words in Tibetan that best describe sustainability? Are [Tibetan nomadic and monastic] livelihoods sustainable? How engineers are connected with the environmental problems? How your culture and Buddhism can help you create engineering designs that supports sustainability? Note: There were other questions in this lesson, but I don’t consider them “reflective” because I wrote a possible answer in the slide.
3.2	How sustainable engineering relates to the processes of recycling paper?
4.1	What would be the environmental and societal impacts of building dams? Imagine that you are a civil engineer. What would you make different to prevent these impacts from happening? Could the mechanical energy generated by moving the tensed cord of a *mani* wheel [ritual instrument used in Tibetan Buddhism] be used to recharge a battery?
4.2	What do you know about energy alternatives in Tibet? Which technologies could be more suitable? Which technologies could harm more Tibet’s environment? Note: I primarily showed videos about energy alternative technologies and how they work.

Appendix Z Videos shown per class

Lesson	Video(s)
1.1	No videos were shown
1.2	No videos were shown
2.1	No videos were shown
2.2	No videos were shown
3.1	*India's E-Waste Recycling Industry*. (2010). Retrieved from http://www.youtube.com/watch?v=8AS9n8ioe4Y&feature=youtube_gdata_player *The Story of Electronics*. (2010). Retrieved from http://www.youtube.com/watch?v=sW_7i6T_H78&feature=youtube_gdata_player *The Ultimate Roller Coaster Ride: An Abbreviated History of Fossil Fuels*. (2010). Retrieved from http://www.youtube.com/watch?v=cJ-J91SwP8w&feature=youtube_gdata_player
3.2	*Plasticycle Technologies*. (2008). Ramp Media Lab. Retrieved from http://www.youtube.com/watch?v=6Y7PKyQ7Sfg&feature=youtube_gdata_player
4.1	I showed a video about how a generator works, but the video is no longer available over the Internet (as of July 3, 2014).
4.2	*Fukushima Incidence Explained*. (2011). Retrieved from http://www.youtube.com/watch?v=YarjI1FwsuA&feature=youtube_gdata_player *How a Geothermal Plant Works*. (2007). Retrieved from http://www.youtube.com/watch?v=kjpp2MQffnw&feature=youtube_gdata_player *How it Works: Hydroelectric Power*. (n.d.). Retrieved from http://www.youtube.com/watch?v=Pj4dZM4SIls&feature=youtube_gdata_player *How Solar Energy Panels Work*. (n.d.). Retrieved from http://www.youtube.com/watch?v=AmWrGPKcMNM&feature=youtube_gdata_player *Nuclear Energy: How it Works*. (2009). Retrieved from http://www.youtube.com/watch?v=VJfIbBDR3e8&feature=youtube_gdata_player *Ocean Energy - Wave Power Station*. (2009). Retrieved from http://www.youtube.com/watch?v=gcStpg3i5V8&feature=youtube_gdata_player *What's Inside a Wind Turbine?* (2010). Retrieved from http://www.youtube.com/watch?v=LNXTm7aHvWc&feature=youtube_gdata_player

Appendix AA Changes made between one report and the subsequent one

Transition	Major changes
Report 1 to 2	The structure of the report changed. In Report 1, these were the sections that I defined: (a) Instructions, (b) Other Questions to Answer, and (c) Rules. My biggest mistake in designing Report 1 was that I included questions in the instructions section as well. In Report 2, I wrote only questions in the "Questions" section, and I kept the sections "Instructions" and "Rules."
Report 2 to 3	Report 3 had the same structure of Report 2; however I separated in a rectangle those questions about "culture and Buddhism" to highlight that I needed them to reflect on them, since some teams were either skipping them or answering vaguely. Later on I realized why this was happening. I asked about Buddhist philosophy topics that have been attributed in traditional Tibetan Buddhist society as a knowledge that is learned by monastics and not laypersons, unlike in Western Buddhist centers. Refer to chapter 5 for a discussion about this misaligned between my methods of teaching and their views of Buddhism as they have learned in their traditional society.
Report 3 to final project presentation guidelines	In this Report, I presented the guidelines in a table. The left column had the presentation slide number. The right column described what I needed in the presentation and if the slide content was required or optional. Refer to Appendix D to see this guideline.

Appendix BB Main references used to design the lesson content (not including image sources)

Lesson	References
1.1	Eggert, R. J. (2005). *Engineering design*. Upper Saddle River, N.J.: Pearson/Prentice Hall. Dym, C. L., & Little, P. (2000). *Engineering design: a project-based introduction*. New York: John Wiley.
1.2	Baillie, C. (2009). *Engineering and society working towards social justice. Part I, Part I,* [San Rafael, Calif.]: Morgan & Claypool Publishers. Retrieved from http://www.morganclaypool.com/doi/abs/10.2200/S00136ED1V01Y200905ETS008 Lucena, J., Schneider, J., & Leydens, J. A. (2010). Engineering and Sustainable Community Development. *Synthesis Lectures on Engineers, Technology and Society*, *5*(1), 1–230. doi:10.2200/S00247ED1V01Y201001ETS011
2.1	Eggert, R. J. (2005). *Engineering design*. Upper Saddle River, N.J.: Pearson/Prentice Hall. Bhatia, S. K., & Smith, J. L. (2008). Bridging the gap between engineering and the global world: A case study of the coconut (coir) fiber industry in Kerala, India. *Synthesis Lectures on Engineers, Technology and Society*, *3*(1), 1–58. doi:10.2200/S00112ED1V01Y200804ETS006 U.S. Congress, Office of Technology Assessment. (1993). *Biopolymers: Making materials nature's way*. Washington, DC: U.S. Government Printing Office. Retrieved from www.princeton.edu/~ota/disk1/1993/9313/9313.PDF http://agproducts.unl.edu/biopolymers.htm (Web page unavailable as of July 8, 2014)
2.2	Garrison, P. (2005). *Basic structures for engineers and architects*. Oxford, UK: Blackwell. USC School of Architecture. (2011). *Rammed Earth Construction*. Retrieved from http://arch.usc.edu/Programs/Research/RammedEarthConstruction. (Web page unavailable as of July 8, 2014).
3.1	2011. Hoffmann, Stephen R., Pawley, A. L., Rao, R., Cardella, M. E., Ohland, M.W. "Defining "Sustainable Engineering": A Comparative Analysis of Published Sustainability Principles and Existing Courses." Paper presented at the 118th ASEE Conference. Miller, G. T. (2005). *Living in the environment: Principles, connections, and solutions*. Pacific Grove, CA: Thomson Brooks/Cole. Baillie, C. (2004). *Green composites: Polymer composites and the environment*. Boca Raton: CRC Press
3.2	Baillie, C. (2004). *Green composites: Polymer composites and the environment*. Boca Raton: CRC Press Waste for Life. (2013). *Waste for Life*. Retrieved from http://wasteforlife.org/

4.1	Miller, G. T. (2005). *Living in the environment: Principles, connections, and solutions*. Pacific Grove, CA: Thomson Brooks/Cole. Smil, V. (2006). *Energy: A beginner's guide*. Oxford: Oneworld. González Velasco, J. (2009). *Energías renovables*. Barcelona: Reverté. Nave, C. R. 2014. *HyperPhysics: Work-Energy Principle*. Retrieved from http://hyperphysics.phy-astr.gsu.edu/hbase/work.html U.S. Energy Information Administration. (n.d.). *Forms of Energy.* Retrieved from http://www.eia.gov/kids/energy.cfm?page=about_forms_of_energy-basics
4.2	http://www.energyfuturecoalition.org/biofuels/fact_ethanol.htm (Web page unavailable as of July 8, 2014) U.S. Department of Energy. (2009). *Biomass program: Information resources : ABC's of biofuels.* Retrieved from http://www1.eere.energy.gov/biomass/abcs_biofuels.html. (Web page unavailable as of July 8, 2014) Miller, G. T. (2005). *Living in the environment: Principles, connections, and solutions*. Pacific Grove, CA: Thomson Brooks/Cole. Hodge, B. K. (2010). *Alternative energy systems and applications*. Hoboken, NJ: Wiley.

Appendix CC Course syllabus

Course Syllabus of "Introduction to Engineering" (taught at TCV Selakui)

Teacher's name: Marisol Mercado Santiago (you can call me "Marisol" ☺)
Teacher's e-mail: mercado@purdue.edu

I. Class dates and time:

- **Days**: Mondays and Wednesdays. **Starting from September 3rd and ending on September 28th.**
- Course project presentation will be tentatively on October 5th or 12th.
- Fridays are to meet individually with groups that need help. At the Multimedia Room.
- **Time:** 4:30 – 5:30 PM.
- **Location:** Multimedia room

II. Course Objectives:

- Provide a general understanding of what is engineering and sustainability
  - More emphasis in sustainable energy technologies, career mentoring, basics of structural engineering, and basics of products design
- Help you understand the connection between engineering and society (and vice versa)
- Help you have a hands-on experience in engineering through a design project, adapted to pre-college students.
- Reflect on how your values, beliefs, and identity as a Tibetan influence engineering

III. What I expect from you:

- You should attend at least 4 out of 6 classes on Mondays and Wednesdays.
- You have to write your name in the attendance sheet every time you attend class.
- **This course requires you to do an "engineering design project." The course project is compulsory. It will be graded as a "Science Day project," so please be mindful of this in your group.**
- Your primary science teacher will grade your project as a "science day project"
- You should use your hour on Fridays to do your course project or write next week's report.
- You *might* need additional time in the weekend or week to finish the course project.

IV. What you expect from me:

- I will provide a *copy of the electronic presentations (slides)*. I will also provide copy of other supplementary materials for each class lesson.
- *If you need help* with your project, the best is to talk with me on Fridays. Alternatively, we can arrange a meeting in the high school. You can also approach me if you see me around in school.
- *If you did not come to class* and you wish copy of the lesson, please tell me so to give you a copy.

- *English is not my first language. If you did not understand something I said in class*, you are welcome to raise your hand to ask me, ask the teacher assistant, or talk to me after class.
- I may not know all the answers to your questions. ☺ If I don't have the information, I will bring it to the next class. ☺
- If a Holiday conflicts with a class, the class will be re-scheduled.

V. Course organization

Date (September)	**Topic**
Monday 3rd	What is engineering?
Wednesday 5th	Engineering and society
Monday 10th	Basic concepts of structural engineering
Wednesday 12th	Basic concepts of products design
Monday 17th	What is sustainability?
Wednesday 19th	Examples of sustainable engineering designs
Monday 24th	Energy and energy alternatives
Wednesday 26th	How do alternative energy technologies work?

VI. Overview of the Engineering Design Project:

Question: What is the difference between this class project and a Science Day project?
Answer:
In your team, you will all work to accomplish the following:

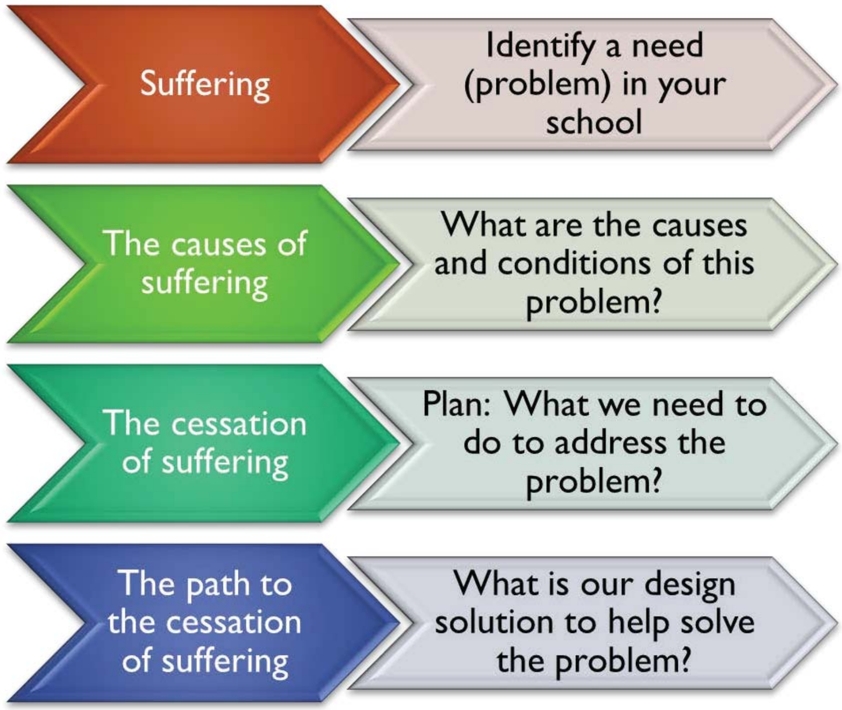
d. *Identify* a problem (need) in your school: research more to understand it
    i. The project will address a real need in your school
e. *Apply* science knowledge and creativity to help solve it
f. *Reflect* on the following: how your Tibetan identity, beliefs, and values are helping you in teamwork and in solving the problem

Distribution of tasks in the group:

You will arrange with your group a fair distribution of tasks in order to complete the project. If you need to rotate tasks every week, please do so. You can use your previous knowledge working on *shenpen* activities or other school teams to manage team-work.

General rules:

- You will be working in a group of 4 students (only one group will have 3 students)
- You will pass through a 4-phase engineering design project. It is based on the Four Noble Truths:



- In your group, after you research about the need in your school, you should support yourself with geometry, physics, and other science principles to create a solution for the problem.
- The need (problem) that you choose must be something that you are comfortable to work with.
- You can ask others in your school to help you (example: people with more carpentry knowledge); however*, you have to write in your report which person helped you.*
- For the project, you should use materials that are environmentally-friendly. It would be great if they are locally available. You can recycle/reuse things.

VI. Project Reports:

Group reports:

There are 4 progress reports as part of the project. On Wednesday September 12th, 19th , and 26th your group needs to submit a report based on a questions sheet that I gave you on the previous week. See the schedule below:

Report number	I will give questions on September	DUE DATE TO SUBMIT REPORT
1	Monday 3rd	Wednesday 12th
2	Monday 10th	Wednesday 19th
3	Monday 17th	Wednesday 26th
4	Monday 24th	On the day when you will present your engineering design project. Tentative date: October 5th or 12th or on the Science Day

You should submit your report in the due date. If external things happened that did not help you to submit the report on time, please tell me so to find other date of submission.

Even though this is an engineering design project, your project will be graded as a Science Day project by your primary science teacher. It might be displayed on Science Day (check with the Principal later).

Language of reports:
Reports must be written in English, please. ☺ They can be handwritten. If you need paper to write your reports, please tell me so. It is not necessary to submit a file/plastic cover with the report.

Any digital photos that you wish to add in your reports can be put in a flash drive or in a DVD. I will pass them to my laptop. Alternatively, bring the camera with cable on the day of your report submission. If you need a flash drive, I will bring one to the class.

Length of reports:
Each report should be 1-5 pages.

VII. Accommodations:

If you have special needs, please let me know. We will make arrangements to help you succeed in the class.

Appendix DD Team members and leader form

1. Write the names of those in your group:
    1)
    2)
    3)
    4)
2. Circle or checkmark (✓) your **group leader** from the names above
3. **Why** you chose him or her as a group leader? (*Examples: previous experience as a leader, knowledge in [X class subject], artistic creativity, etc.*)

VITA

VITA

Marisol Mercado Santiago

Education

Doctor of Philosophy in Engineering Education Purdue University, School of Engineering Education National Science Foundation Graduate Research Fellow (2011-2014) Adviser: Dr. Alice L. Pawley	December 2014
Master of Engineering in Computer Engineering Polytechnic University of Puerto Rico	May 2009
Bachelor of Science in Computer Science Inter-American University of Puerto Rico	May 2006

Work Experience

Research Assistant **"Learning from Small Numbers" Research Study** o Summarizing journal articles, processing transcripts, and editing bibliographies.	August—December 2014
Doctoral research summary: **"Culturally responsive engineering education: A case study of a pre-college introductory engineering course at Tibetan Children's Village School of Selakui"** o Obtained grant from NSF Graduate Research Fellowship to conduct research on (a) How Tibetan culture and Buddhism influence student teams' design and teamwork experiences and (b) What are the processes to develop and implement a culturally responsive pre-college introductory engineering course. o Developed and taught a pre-college introductory engineering course with emphasis on sustainability. o Research results may inform educators who are working on culturally responsive ways of teaching to underrepresented ethnic minorities, refugee or ethnic diaspora students in the United States.	

Doctoral research fieldwork: ***Locations:* Dharamsala (Himachal Pradesh, India) and Dehradun (Uttarakhand, India)** o Managed to obtain access to Tibetan Children's Village (TCV) School of Selakui while in Dharamsala. o Taught pre-college introductory engineering to secondary school Tibetan students at TCV Selakui (a six-week course). o Worked with the school administration to arrange teams' design projects presentations at the school auditorium. o Designed and distributed certificates to students. o Supervised a teacher assistant (a student). o Recruited and interviewed research participants.	April—December 2012
Research Assistant **ADVANCE-Purdue Parental Leave Research Study** o Recruited and interviewed participants (consisting mostly of department heads and professors). o Analyzed transcripts with NVivo qualitative data analysis software. o Wrote a literature review on parental leave policies.	August 2010—July 2011

Technical and Programming Skills

o Visual Basic.NET, C#.NET, ASP.NET o Visual Basic 8 o JSP (Java Server Pages) o HTML, XML, JavaScript o Perl, UNIX command language	Programming skills
o Database design, implementation, and administration using Microsoft SQL Server o Crystal Reports.NET	Database skills
o Microsoft Office: Word, Access, Power Point, Excel, and Visio o TrueCrypt (encryption software) o NVivo (qualitative research software) o GIMP (image manipulation software) o Linux- and Windows-based systems o Antivirus, Web browsers, e-mail programs, intrusion detection software	Software skills
o Diagnosis and repair of Windows-based computer systems o Assembly and installation of Windows-based desktops o UML (Unified Modeling Language)	Other technical skills

Publications and Presentations

Schimpf, C., Santiago, M. M., Hoegh, J., Banerjee, D., & Pawley, A. (2013). STEM faculty and parental leave: Understanding an institution's policy within a national policy context through structuration theory. *International Journal of Gender, Science and Technology*, *5*(2), 102–125.

Santiago, M. M. (2013). What can Buddhism offer to a socially just engineering education? In J. Lucena (Ed.), *Engineering Education for Social Justice: Critical Explorations and Opportunities*. Springer: Netherlands.

Santiago, M. M. (2011, July). *The ger and engineering*. Presentation given at the Mongolian Language and Cultural Camp, Bloomington, IN.

Mercado Santiago, M., Pawley, A. L., Hoegh, J., & Banerjee, D. (2011, June). *Institutional ethnography as a method to understand the career and parental leave experiences of STEM faculty members.* Paper presented at the 118th ASEE Annual Conference & Exposition, Vancouver, BC.

Mercado Santiago, M. (2011, June). *Introduction to engineering integrating Tibetan culture and Buddhism*. Workshop given at the 12th Sakyadhita International Conference on Buddhist Women. Bangkok, Thailand.

Mercado Santiago, M. (2011, June). *Buddhism in culturally responsive engineering and science education.* Paper presented at the 12th Sakyadhita International Conference on Buddhist Women. Bangkok, Thailand.

Mercado-Santiago, M. (2010, July*). Toward an indigenized engineering education: Andean peasant technologies as engineering education resources for Andean peoples*. Paper presented at the VIII Jornadas Latinoamericanas de Estudios Sociales de la Ciencia y Tecnología. Buenos Aires, Argentina.

Web Publications

Tally, L. (2013, April). *Ph.D. program: Introducing engineering to Tibetan children*. Retrieved from https://engineering.purdue.edu/ENE/Newsletters/ENEws/Spring%202013/research-engineering-education-for-tibetans-in-exile

TCV Selakui Blog. (2012, October 18). Project "Introductory Engineering." Retrieved from http://tcvmagnetschoolworkpress.wordpress.com/2012/10/18/project-introductory-engineering

Continuing Education

- Applied Management Principles (Krannert Executive Education Program, Purdue University)

Language Skills

- Spanish and English (fully bilingual)

Awards

- NSF Graduate Research Fellowship (2011-2014)
- Summa Cum Laude (2006)

Service

Mentored Engineering Education doctoral students at Purdue University (consisting mostly of minority and international).	2013
Mentored Tibetan high school students at Tibetan Children's Village School, Selakui, and over the Internet.	2012-2013
Meeting manager of Dr. Alice L. Pawley's research group at Purdue University.	2010-2011, 2013-2014
Served and prepared food for low-income and homeless individuals as part of a non-profit organization initiative in San Juan, Puerto Rico.	2008-2009